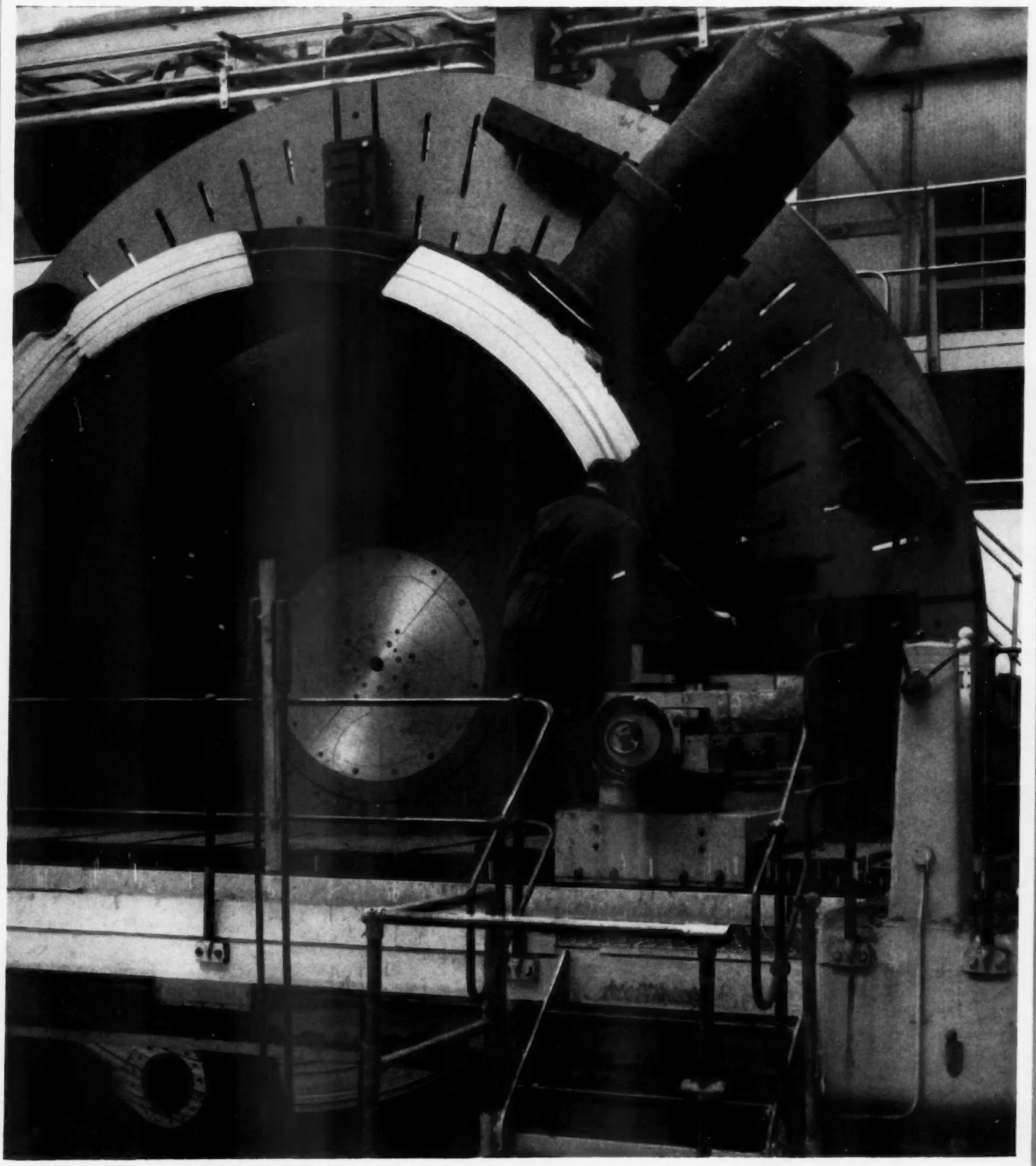
ENGINEERING 8-2-57

ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 183 No. 4744 *LONDON, FRIDAY, FEBRUARY* 8, 1957 PRICE 2s.



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Published every Friday by Engineering Limited, 35 & 36 *Bedford Street Strand, London, W.C.*2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s., Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* (2*s.* 3*d.*)

FROM LIES TO STATISTICS

It is something like a century since Disraeli was able to make political capital out of his aphorism about lies, damn lies and statistics. To-day, Governments use statistical tools as instruments of policy, and in the western world, at least, figures are published so that official interpretations can be leavened by independent appraisal and comment. The process by which economic statistics in particular have changed from being mainly a record of the past to an aid for forecasting future developments and helping to delineate public economic policy has been slow to develop and delayed by prejudice. When Disraeli put statistics and lies in the same sentence he provided a handy cudgel for the critics to use on those bold pioneers who first used statistical methods for economic crystal gazing.

The critics have been of two kinds. There have been those from the well established branches of knowledge, among whom may be placed the engineers, who have been unimpressed with the claims of economic statisticians that they were scientific in their methods. An engineer who builds an arch bridge can calculate the point at which the two segments of the arch which spans the river will meet. A statistician who tries to span a ten year period of human behaviour in economics and politics is fortunate if he can sling even a flimsy ropeway across the years.

The second group of critics have unfortunately been those whose co-operation has been vital for improving statistical information. These are the trades and industries whose experience the statistician is trying to distil and use to read the future. Companies have been anything from fully co-operative to vociferously hostile in the past when they have been asked to provide figures, confidential or otherwise, about their trading experience. Their criticisms have come partly because they see no reason why they should divulge their private affairs, partly because extracting figures takes time and money and partly because until recently few companies appreciated the value of general statistical information as a background to their own trading experience and forecasting.

It took the great depression of the 1930's for the statistical enthusiasts to win any general support, official or otherwise, for the development of a systematic and comprehensive statistical record of the country's economic life. By the early 1930's it had become pathetically evident that some at least of the suffering and misjudgment which had brought about world depression was due to the fact that governments were lacking the statistical tools for analysing thoroughly what had gone wrong, or for foreseeing what would happen in the near future to the economic system if certain lines of policy were adopted.

Among the groups interested in this subject, and one which early saw the terrible price which had been paid for statistical ignorance, was Political and Economic Planning. It is fitting that now, nearly a quarter of a century later, P.E.P. should have published a broadsheet on the use of statistics in government. The significance of the brochure is its timing: further recent advances have been made in the provision of official statistics, of which quarterly figures for public expenditure are the latest development.

P.E.P. have reviewed the progress of Government statistics over the last 25 years in particular and rightly point out the great impetus to their publication which was given by the war. For example, the well known *Monthly Digest of Statistics* began as a confidential compilation of statistics for Government departments in the war years. After the war it was made a regularly published collection of economic statistics and it has been extended in scope on many occasions since. Much of the progress with statistical work in recent years has been built on the development of sound sampling methods. Where statistics are scanty or the statistical universe is particularly large it is clearly necessary to use a sampling technique, and here a certain imaginativeness and boldness is necessary. A recent example of the usefulness of sampling, and one of vital importance to the engineering industry, is the sample of opinions taken from industry of the capital invested in plant and equipment for a period in the recent past and their indications for a similar period in the future.

The main criticisms of this country's national economic statistics are, according to P.E.P., that there is too big a time lag between collection and publication, that revisions are made too frequently and that they are insufficiently analysed. It is apparent, however, that there must be gradual progress on all these three fronts at once, for a too hasty publication of results will create the need for further revision and so the vicious circle will go on. Probably one of the most important steps which can be taken in handling official statistics would be to increase further the use of all types of computers.

To-day, the prejudice against economic statistics has been considerably reduced. There is still a certain amount of good-natured scepticism from natural scientists about the scientific validity of some of the methods used by the economic statisticians. More and more, however, they are coming to realise that he who deals with the human factor must allow for an unknown variable which eludes any formula or form of computation. Their criticism must also be tempered by the

successes which the economic statisticians can claim in the broader fields of their work. They can claim that an economic policy of full employment has been maintained in this country for 20 years, thanks in part to avoiding action being taken in time—action which was based to no small extent on figures. It is indeed interesting that if more information had been available about the state of industry's stock holdings of materials and finished goods in 1954 the "inventory boom" of that autumn might well have been foreseen and controlled. Both in the board room and among managers it is increasingly appreciated that such forecasts of the industrial climate are a vital instrument in fashioning company policy to-day.

Statistics for Government, P.E.P. (2*s* 6*d*.)

* * *

Plain Words

Unqualified respectability has never been accorded to the specialist in this country. The ability to resolve detailed problems has been condemned as "bad form" and certainly not worthy of great reward. Better appreciation of the specialist—whether he is the occupant of a university chair or in industry—is therefore to be welcomed. Specialisation is not a sin.

The first chair of engineering was established in 1838 at King's College, London. Since those very early days many chairs of engineering have been founded. And, fortunately, there have been appointments at professorial level where the field of interest has been limited: chairs of telecommunications, without reference to electrical power; of thermodynamics, with no implied responsibility for theory of machines or strength of materials. For civil engineers, there have been independent chairs of hydraulics, municipal engineering, surveying (and of late, quite separately, of photogrammetry) as well as soil mechanics and concrete. Yet not until this last month has there been a chair of structural engineering in a British university: not until the University Council and the Governors of the Manchester College of Science and Technology approved the appointment of Dr. Wilfred Merchant, M.I.Struct.E., hitherto Reader in Applied Mechanics, as Professor of Structural Engineering.

There have, of course, been many eminent professors of engineering who have specialised in structures, and have been promoters of the art. Some have made great contributions to that branch of theoretical analysis; some have advised and assisted in the design of large buildings, of bridges and of dams. Many, using theory of structures as their medium, have inculcated the principles of an engineering approach into their students. But they have mostly been professors of civil engineering. They have had a title that covers a wide field even though, in practice, they may have specialised. It is right to resist specialisation during the early years of education and training, but when a man is well launched on his career his function should become more and more specialised.

MORE GOODS BY TRAIN SPURS THE WORLD'S RAILWAYS

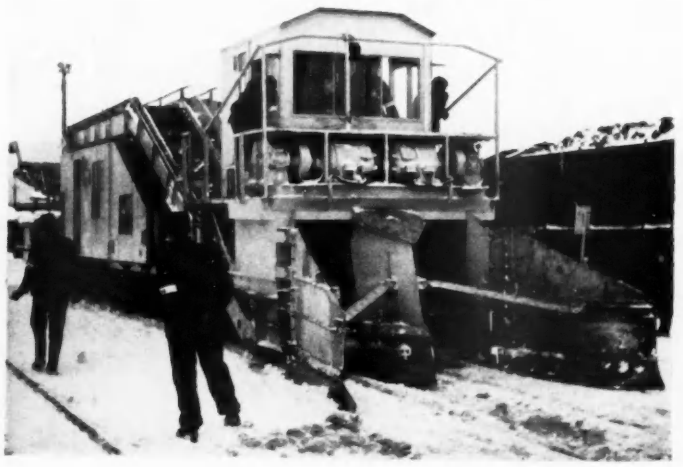
A quick look at the railways of the world is enough to show that in spite of competition from road and air transport, rail traffic continues to increase. One estimate puts the increase of traffic which the railways will have to carry in ten years' time at 40 per cent. So much for the extremists who argue that the permanent way should be torn up and main roads laid on the foundation thus provided.

The response of railway administrations to this challenge varies widely, according to the availability of different fuels, money for capital developments, and the degree of wide-awakeness of the headquarters and staff. In this country we are apt to assume that electrification is the most highly developed form of traction, yet in the United States some of the railways that have used electric traction for many years are now in process of going over to Diesel power. Construction of new track is restricted almost entirely to under-developed parts of the world, though it includes the U.S.S.R. where certain regions still come in this category.

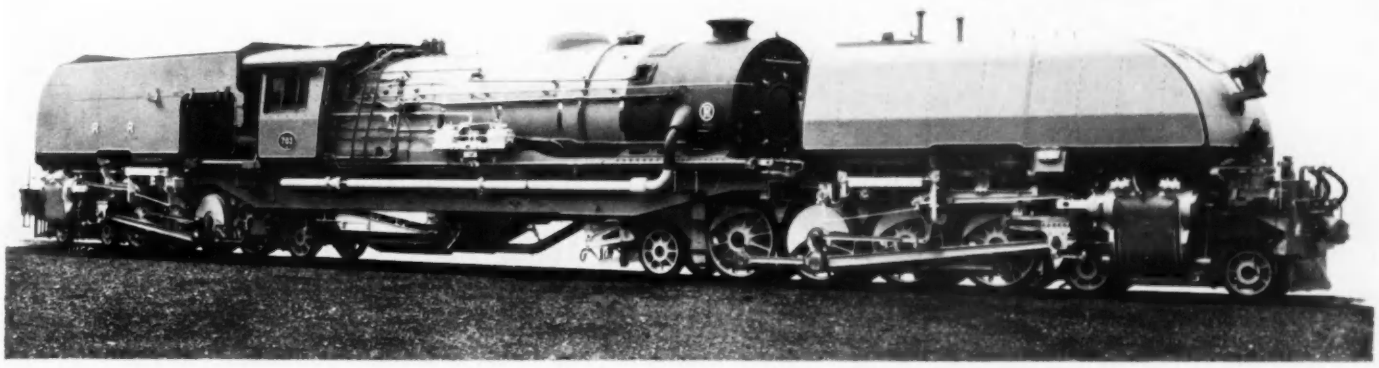
The recently published fourth edition of *World Railways* gives details for the first time of Russian and Chinese railways. The Soviet Railway System is described as "the largest individual railway system" in the world (it has a total route mileage of 74,565). Some indication of the serious effects on transport costs which arise in large and scattered countries is given by the figures for length of haul of freight. In the U.S.S.R. a ton of goods is transported an average distance of 476 miles; in the United Kingdom the average distance is only 72·8 miles. Clearly, a small highly industrialised country has an immediate advantage. The Soviet Railway System is reported to have made a gross profit of 16,800 million roubles in 1955. Since the second World War construction has included some new lines as well as work on the restoration of war damage.

When *World Railways* was launched after the war, its value as a reference work on the lines of *Jane's All the World's Aircraft* and *Jane's Fighting Ships*, was apparent, but it was equally apparent that the editor and publisher would have immense difficulty in obtaining all the information they required to make it a complete success. The difficulty has been overcome and the latest edition is not only an essential tool for anyone concerned with supplying railways with equipment and plant, but is also a source book for a comparative study of railway developments throughout the world. The pictures on these pages are a few of those used in the book. They have been chosen to bring out the variety of railway work; indirectly they show the folly of neglecting improvements, since the application of technical developments to transport is a continuing need whatever the political or economic situation in a country.

Since most of the anticipated increase of traffic will have to be carried on existing tracks, the only way it can be done is to make railway operation more efficient, using every available invention and development. Railway administrations everywhere have either announced or are proceeding with extensive programmes of improvement. Better braking, improved signalling, traffic control and communications, provision of better marshalling



A Diesel-electric snow loader which disposes of 706 cub. ft. of snow a minute in Japan.



One of the Beyer-Garratt locomotives that have helped to preserve the traffic efficiency of steam traction on railways where axle loadings are low. The French electric locomotive shown opposite is one of the two which raised the world speed record to 206 m.p.h.

facilities, better loading and unloading facilities, and a general speeding up of traffic all play an important part in these schemes. At no time has there been greater activity, almost everywhere, to modernise railway systems.

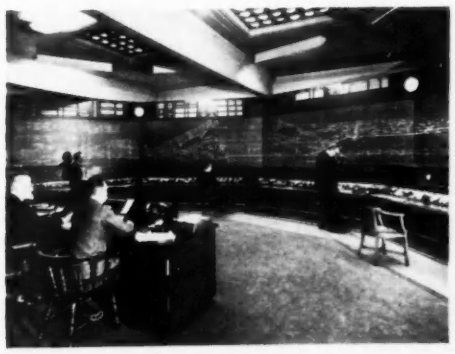
It is at first sight paradoxical, but on reflection logical, that the more straightened the economic situation the greater the need for bringing the system up-to-date. Further, the more antiquated the rolling stock the less the inhibition in replacing it. The Irish State Railways, the first national body to undertake a complete transition from steam to Diesel, when arriving at this decision would not have had to weigh amortisation in the balance to the extent that would have prevailed on railways with more modern stock.

In Europe (excluding U.S.S.R.) the total route length of electrified lines is already about 22,500 miles, and if the published plans are completed a further 6,000 or so miles will be added in the next ten years. In the United States the electrified route length is about 2,000 miles—something under 1 per cent. of total route mileage and considerably less than the British total. Under the British Railways Modernisation Plan, electrification will proceed apace. In the United States last year the Great Northern Railway replaced electric operation on 74 miles by Diesel power, and the New York, New Haven and Hartford Railway have announced that they will commence to replace electric operation in 1960. But electrification is to be undertaken in Brazil, Chile, South Africa, India, Japan, New South Wales, and Victoria. On the Soviet Railway System the electrification of 5,000 miles is envisaged in the next five years, and plans are being made to electrify up to 25,000 miles in the coming 15 years.

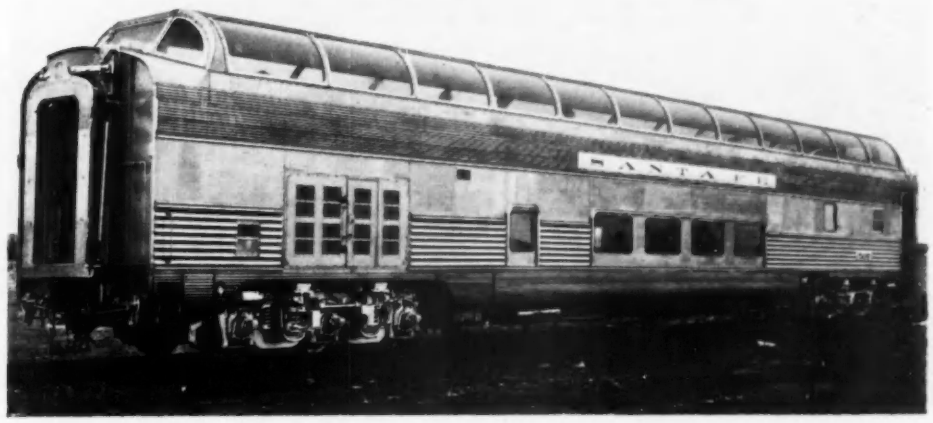
The ubiquitous Diesel continues to progress. There are now over 2,500 Diesel locomotives in Europe, with over 1,000 on order and some 6,000 to 7,000 required during the next few years. If the steam locomotive continued to decline in the United States at the 1956 rate (2,338 in one year), which presumably will not be the case, it would be extinct in under two years, as the total number on September 1, 1956, was 4,343.

While Diesel and electric power, in the forms of railcars, lightweight trains and separate locomotives, continue to flourish, steam locomotives are still being ordered by those administrations which for certain reasons, e.g., cheap coal or high cost of imported oil, consider them

A Type ETR300 electric train on the Italian State Railways.



Modern signalling on British Railways—the signal box at York.



An air-conditioned dome car on the Atchison, Topeka and Santa Fe Railroad, U.S.A.

Electrically operated track-lifting and ballast-moving equipment on the Soviet Railway System.

American " Piggyback " rail-road transport, using railway-owned road freight trailers.

more suitable. South Africa and India remain strongholds of steam, mainly because of cheap coal supplies. The railways of these countries, the U.S.S.R. and China are among those intending to increase their stock of steam locomotives. A noteworthy order secured by Britain recently was for a further 95 Beyer-Garratt locomotives, now being delivered to the South African Railways.

World Railways gives details of 1,470 railways. Though future policy varies widely, especially in the choice of motive power, it is clear that no country can afford to economise on this basic means of transport. It is clear, also, that a dynamic country usually has a dynamic railway system (though it is possible to think of at least one country that would not be generally accepted as " dynamic " yet has a remarkable railway system). There is no inherent reason why railway engineering should not be every bit as interesting as any other branch of engineering, provided the opportunity to exploit modern developments is not wasted or frustrated.

World Railways 1956-57. Edited and compiled by Henry Sampson. Sampson Low's " World Railways " Ltd., 25 Gilbert-street, London, W.1. (84*s.*)

SKYLARKS WILL RISE IN AUSTRALIA

High Altitude Research Vehicle for I.G.Y.

Test firings of the first of Britain's Skylark high-altitude research vehicles, which is to take part in the International Geophysical Year activities, are to begin soon at the Woomera range in Australia. The Skylark is powered by Raven rocket motors built by Bristol Aircraft Limited (Weston Division) in collaboration with the Royal Aircraft Establishment, Westcott. It is expected to reach a height of 70 miles in its initial version; more advanced models are designed to reach 120 miles. The Skylark is 25 ft. long and 17½ in. in diameter. Its Raven rocket motor is 18 ft. long and will give a thrust of 11,500 lb. for about 30 seconds.

The Skylark is stabilised by three swept-back fins. It will be fired up an 80 ft. long launching tower which weighs 30 tons. A second launcher is being constructed at the Guided Weapons range at Aberporth, Wales. When the tests at Woomera (where the range is much larger) have shown that the Skylark's trajectory can be confidently predicted, part of the research programme will be transferred to Aberporth.

During the International Geophysical Year flights which are due to start in Australia in July, attempts will be made to discover further information about the upper atmosphere. The apparatus necessary for the proposed experiments is being built by a number of British universities under the general supervision of the Royal Society and the R.A.E.

Tests to discover temperatures and winds at altitudes between 20 and 60 miles will be carried out by photo-electric methods, and winds between 10 and 50 miles up will be determined by the radar tracking of " window " (strips of tin foil) released from the rocket. Among other factors which will be determined are the nature and abundance of atmospheric ions, and the density of electrons at various altitudes.

THE SUPERSONIC AIRLINER

On Friday, January 25, the front-page headline of the *News Chronicle* proclaimed that " Britain Plans Sky Queen," and went on to say that, sponsored by the Ministry of Supply, seven aircraft firms—Avro, Bristol, de Havilland, Handley Page, Rolls-Royce, Short Brothers and Harland, and Vickers-Armstrongs (Aircraft), were co-operating in the planning of a supersonic airliner which, they surmised, would have to fly at about 1,100 m.p.h. " to be a useful advance on the 600 m.p.h. long-range jet air-liners already being built in America." The deluge of inquiries which followed drew from the Ministry of Supply the statement that, indeed, a research project is now under way " with a view to the possible development of a supersonic airliner " and that, as the *News Chronicle* had said, the seven firms, with the co-operation of the national air-line corporations and the Royal Aircraft Establishment, were participating in a joint venture. The Ministry declined, however, to disclose any details of the nature of the project. There can be little doubt that it is still in the very early exploratory stages.

As *The Times* pointed out the following day, Sir Arnold Hall, technical director of the Hawker Siddeley group (which includes Avro), has thrown some light on the possibilities and difficulties of supersonic commercial flight, on the basis of present-day knowledge, in the Wright Brothers Lecture delivered before the Institute of Aeronautical Sciences in Washington in December last. Whereas the introduction of the high subsonic-speed jet air-liners can be expected to result in distinctly lower operating costs than those of the commercial aircraft in service to-day, the supersonic air-liner will, on the contrary, cost substantially more to operate than the high subsonic aircraft. In what he described as the " low-supersonic " class—up to Mach 1·5—recent aerodynamic investigations have given some grounds for hoping that the onset of wave drag may be further delayed, possibly by extending the " area rule " to specify not only the cross-sectional area but also the cross-sectional shape of the body; should it thus prove possible to achieve a worthwhile increase in the lift/drag ratio to, say, 14 in the low-supersonic régime, trans-atlantic operations at low-supersonic speed might prove economically feasible although still costing more to fly than the 600 m.p.h. aeroplanes.

In the medium-supersonic range, from Mach 1·5 to 3, the possiblities of improving the lift/drag ratio beyond about 6 by delaying the onset of wave drag are not promising with conventional configurations, but, owing to the fact that the efficiency of the turbojet engine increases with speed and is at its best at around Mach 2·5, medium-supersonic long-range flight over still-air ranges of 3,500 to 4,000 miles should be possible and not too costly for " the smaller section of the market which is concerned more with time and comfort " (than with minimum cost). The 5,000 mile range necessary for trans-atlantic operation would, however, be very difficult to achieve, since in this régime the performance of the aircraft is very sensitive to small departures from the design ideal. At the present stage it would, moreover, not be prudent to consider speeds above Mach 1·8 or Mach 2, at which the effects of kinetic heating become appreciable and would demand the use of stainless steels and titanium alloys for the structure, and rigorous cooling systems for the cabin and components.

With the advent of the medium-supersonic airliner, radical changes in configuration may take place in order to make use of engine-generated lift for take-off and landing, and thereby to reduce the structure weight, such as the narrow-delta layout suggested by Dr. A. A. Griffith of Rolls-Royce Limited in conjunction with vertical-lift engines. The latter, however, are likely to prove too noisy to be acceptable for city-centre commercial operation, and for operation from conventional runways; " blowing over the flaps " may provide a better solution for low-speed performance.

Letters to the Editor

ENGINEERING CONTRACTS

SIR, As an electrical engineer concerned with contracts for the erection of power plants in India, I have read with keen interest the tenth article of the series on engineering contracts, entitled " Defects and the Maintenance Period," published on page 713 of the December 7, 1956, issue of ENGINEERING.

If I may be allowed to offer my comments on Mr. F. H. B. Layfield's article, I would point out that the " defects liability clause," as it stands, does not safeguard the contractor in any way in the event of " taking over " being unduly delayed owing to causes beyond his control, since the " defects liability period " is linked to the date of the taking over, or the " substantial completion," of the works. As an example, I may cite the case of hydro-electric power plants, where the completion of the hydraulic and other civil-engineering works, such as the construction of the dam, may delay the installation and commissioning of the power plant by as much as from three to four years. The machinery suppliers obviously have no influence or control over the date of completion of such civil-engineering works. In conformity with the contract, they may have delivered the machinery to the site. It will be appreciated that the condition and performance of such machinery, when stored on the site pending its installation, may be very adversely affected after an unduly long period. The task of storing is usually undertaken by the engineer and may not be carried out under optimum conditions, thereby leading to a further down-grading in the performance of the plant concerned.

I feel, therefore, that a limiting period should be imposed upon the utilisation of " defects liability " guarantees. In other words, there should be a specified period, counted from the date of delivery of the plant at the " port of entry " or to the site, as the case may be, during which the " defects liability guarantee " of 12 months (or whatever period has been agreed upon) may be utilisable. Should the taking over be delayed beyond this " defects liability limiting period," owing to causes outside the contractor's control, the " defects liability guarantee " should automatically expire. I believe that such a provision would afford protection to the contractor, in the event of the plant supplied by him being down-graded owing to long and careless storage.

In his summary of the article, Mr. Layfield points out that only the engineer can decide how long the maintenance period should last. This statement implies that the engineer is at liberty to specify periods considerably longer than the 12 months set out in clause 29 (i) of form " A " of the Institutions of Mechanical, Electrical and Consulting Engineers. May I express the view that such freedom to fix the maintenance period, if given to the engineer, might, in certain cases, stretch reputable manufacturers of machinery beyond the " elastic limit " ?

Your faithfully,
M. S. MALANEY.

Burgschmietstrasse 8,
Nürnberg,
Western Germany.
January 30, 1957.

★ ★ ★

VIRTUAL WORK AND THE MOMENT DISTRIBUTION METHOD

SIR, There seems to be some confusion in reconciling the sign conventions used in moment distribution and those used normally for bending moment diagrams, and Professor B. G. Neal's article under the above title, in your issue of January 11, page 47, is an example in point. In this article, two conventions are given as follows: (*a*) " a bending moment is positive when it is clockwise "; and (*b*) " a bending moment being regarded as positive when it causes tension in the extreme fibres of the member adjacent to the dotted line"—short dotted lines being drawn close to one side of the members on the portal frames in Figs. 1a, 3a, and 4 of the article. Although the dotted lines switch from one side to the other at joints, they do not apparently do so at the centre of a beam. This second convention gives the impression that there is a sudden change of bending moment at each joint, but this is not so, since there is no applied external couple there.

The confusion arises because it does not appear to have been recognised that the term " bending moment " as used in (*a*) and (*b*) refers to different things. In (*a*), it represents a single couple, which may be clockwise or anti-clockwise, whereas, in (*b*), it represents a pair of numerically equal but mutually opposing couples. The latter may perhaps be more appropriately called a " bending action." There are two arrangements of the component couples in a bending action, namely $+-$ and $-+$, one of which arrangements may be called positive and the other negative.

The above distinction between a single couple and a bending action is analogous to that between a single force and a stress. In this connection, the writer regrets the common use of the expression " force in a member," rather than the more correct term " stress." Unfortunately, " stress " has come to be universally accepted in place of " intensity of stress " and has lost its former meaning.

If the above difference in the meaning of " bending moment," as used in moment distribution, and as inferred in drawing bending moment diagrams (or bending action diagrams, as I would prefer to call them) is accepted, then Professor Neal's second convention would appear to be useless: at every section of a beam or frame there would be the two opposing couples and his dotted lines should appear on *both* sides for the whole length of the frame.

In the writer's opinion, a more satisfactory sign convention in place of (*b*) would be as follows. If a point travels along the neutral axis of the members of a frame from A to X, the bending action at a section is positive if the bending moment from the approaching side is clockwise. This would be equivalent to saying that a positive bending action produces tension on the right-hand side of a point travelling in the positive direction along the neutral axis of a member.

Yours faithfully,
J. JENNINGS,
Head, Mechanical Engineering Department.
Technical College,
St. Helens,
Lancashire.
January 29, 1957.

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FARMER'S LAMENT

SIR, I am referred to in your Human Element note under " Farmer Glanfield Victorious," on page 96 of your issue of January 18. Let me say at the outset that I am extremely grateful to you for the publicity which you have given to this matter and for the very constructive argument which you have put forward. Unfortunately, however, your first paragraph is incorrect.

There are two electricity undertakings which both wanted to come across the centre of my farm. The dispute with the Southern Electricity Board was concluded, and an agreement arrived at, on January 5, last. Instead of going straight across my land, as primarily envisaged, with about 400 yards of cable on poles across my fields, the Board agreed to go along my boundary hedge for about 100 yards only. This change meant that only four trees had to be felled instead of more than twenty, and it also meant that, in accordance with the Electricity Supply Act, 1882, the Board was doing me the minimum amount of " damage, detriment and inconvenience." In respect to this agreement with the Southern Electricity Board, the trees have now been felled, the hedge lopped, and the " H " poles cabled. The whole structure was tested and working on January 9, prior to the date of your note.

As regards the demands of the Central Electricity Authority to erect high towers for the super-Grid, this body has put in a defence and counterclaim to my High Court action, and the matter will come before the Queen's Bench early this year for hearing.

Yours faithfully,
D. J. GLANFIELD.

Twelve Oaks Farm,
Windlesham,
Surrey.
January 29, 1957.

Editor's note: A spokesman of the Southern Electricity Board has commented—" The route originally proposed for the Board's line on Mr. Glanfield's land was 200 yards in length only; it would have involved the felling of two elm trees and the lopping of saplings where it crossed the hedgerows, and the line would not have run aaywhere near the centre of Twelve Oaks Farm.

" After amicable negotiations, the route was altered to a position along the boundary hedge which involved, as Mr. Glanfield correctly states, a route length of 100 yards on his land and the felling of four trees. Mr. Glanfield signed a wayleave agreement for this route as long ago as March 23, 1955—the route of the line was not subsequently varied but the amount of compensation to be paid by the Board for the felling of the four trees and the cutting of the hedge has been in dispute. Mr. Glanfield demanded at least five times the amount originally offered, but after the Board had obtained a statutory order from the Minister of Fuel and Power authorising them to cut the trees and hedge, Mr. Glanfield reduced his demand to twice the Board's offer. As the dispute about compensation had already held up completion of this important 33,000 volt line for eight months, the Board accepted Mr. Glanfield's lower figure in order not to subject a large body of consumers to added risks of supply failures in the remaining winter months."

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AN ENGINEER'S CARD INDEX

SIR, I find you have introduced an error in my letter published in your issue of January 25, page 101. The words " What is quicker and more flexible than pasting," should be followed by a comma, not a question mark, since the question mark makes the words look like a rhetorical question instead of, as intended, an adjectival phrase relating to what follows.

In point of fact pasting is far from quick. It is also a messy process and it makes the cards buckle unless a special rubber-based cement is used.

Yours faithfully,
J. E. HOLMSTROM.

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DOWN ON THE FARM

Two techniques predominate among advertising films. One sets out to claim attention in every possible way, employing all manner of trick effects to bemuse and—possibly—confuse. The other tries a more subtle approach. The first relies on a bludgeoning process, the second on gentle persuasion. It is the latter that finds the favour of the British Electrical Development Association in their film " Current affairs ", which sets out to persuade farmers to use electricity as much as possible.

Attention is focused on a particular farmer—one Tom Hunter, a man " shrewd, experienced and not averse to new ideas," a man who would seem a not too distant relative of the Archer family. The deficiencies in his egg and milk production, and the misuse of his tractor, are pointed out, and his subsequent encounters with fellow farmers and the Electricity Board portrayed. The settings are very authentic. The shooting was done in Buckinghamshire with the co-operation of local farmers and the conversation sounded soothingly rural to at least one city-dweller unacquainted with the mysteries of " cash crops " or " concentrates." It must be admitted however that a rather strange effect was achieved when the background music to a cowshed scene was provided by a proficient piano quartet playing a rhythmic blues.

Throughout the film the attempt is made to win over the audience of farmers by showing them farmers like themselves benefitting from electricity. From this point of view it was a pity that the actual financial advantages were not discussed in greater detail.

Weekly Survey

Cover Picture: *The production of large components for heavy capital industry presents machining problems of a unique character. The illustration shows a 23 ft. diameter faceplate lathe with a bale (support) ring for a Bessemer converter in position. The lathe is capable of swinging work 34 ft. in diameter, up to 2 ft. depth from the faceplate and weighing as much as 60 tons. The rotational speed of the faceplate is related to the tool feed to increase with reducing diameter, so giving a constant cutting speed. One of two cutting saddles which operate on a removable saddle gantry is shown in the foreground.*

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Investment and Government Expenditure

It has often been said that the policy of using monetary controls to influence the trade cycle can only be partially effective because such controls will not influence Government expenditure. From the point of view of industry this is no more than saying that in economic affairs there is one law for the rich and another for the poor. How true this is can be seen from the latest quarterly statistics of current and capital expenditure in 1956 put out by the Central Statistical Office as a supplement to *Economic Trends* (H.M.S.O. publication, 2*s.* 6*d.*).

In the first three quarters of 1956, the credit squeeze was beginning to show substantial results. The rate of increase in consumer expenditure (especially in durable household goods and motor cars) was rapidly losing impetus and investment in plant, machinery and dwellings went up by a smaller amount in 1956 than in 1955. Measured at 1948 prices, gross fixed capital formation went up by only 3 per cent. compared with 8 per cent. in the first three quarters of 1955. There was no significant change in the rate of accumulation of stocks by industry. There is evidence, of course, that in the fourth quarter of 1956 the rate of increase fell off even further and may have completely disappeared.

In contrast, public current expenditure increased. Over this period of nine months it seems to have taken about one-quarter of the 2 per cent. increase in the national income. Thus, while the private sector of the economy was having a brake applied to it, the public sector was being accelerated. Defence expenditure played an important part in this outlay and the Suez adventure will have added further to it. The importance of bringing public expenditure into broadly the same pattern as private expenditure is vital if a deflationary policy is to be pursued with discrimination over the next few months. Deflation in the private sector and inflation in the public one will perpetuate the distortion in the flow of manpower and materials which deflation was intended to cure. A cut in public expenditure, especially in defence, already seems to be part of the economic strategy for 1957 and may well be put into the April Budget. But the hopes of a general relaxation in restrictions are not bright until public expenditure, both by the central Government and by local authorities, has had an effective pruning.

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As Others See Us

A distinguished American engineer considers that United States manufacturers will have severe competition from Western Europe in their own domestic market: "The spread between average labour rates in Europe and the United States is wider than at the war's end. Europe is not yet as efficient as we, but with labour rates averaging a third to a quarter of ours, she can still undersell us by more than enough to hurdle our modest tariff wall." This conclusion was reached by Mr. Frederick S. Blackall, Jnr., a past-president and fellow of the American Society of Mechanical Engineers and the president of the Taft-Peirce Manufacturing Company. He came to this country to attend the British Machine Tool Exhibition, where his company showed their surface grinding equipment, and went on to tour the main industrial areas of Western Europe. His commentary on his tour is published in the January issue of *Mechanical Engineering* under the title "Recent Technical and Economic Developments in Western Europe."

Mr. Blackall takes very seriously the discrepancy between the wage rates current in Europe, particularly in Britain and Western Germany, and those current in his country. It is encouraging that so experienced a man should find our competitive potential in North America so strong. For this reason alone it would be worth the Board of Trade's while, or that of the Dollar Export Council, to reprint the article and see that every company employing over 100 people got a copy. But Mr. Blackall is not over complimentary: "the fact that Britain cannot price her goods at a half to a third of our prices seems indicative of a relative lack of efficiency." This is often said here, but the market must play a decisive part in what plant shall be used. If it is small and varied, as is the case for most British companies, high-speed automatics and specials cannot easily be justified. Perhaps Mr. Macmillan's efforts to assist the creation of a free-trade area in Western Europe will change all this. Meanwhile we must accept some (relative) inefficiency when first-class British concerns are compared with first-class American ones.

Mr. Blackall was impressed with "the continuing advances which Europeans, including the British, are making in the field of optics" as applied to machine-tool controls. He mentioned in particular optical measuring and setting devices in jig borers and precision grinding machines. American machine tools, he feels, have priced themselves out of Western European markets. What of British machines in North American markets? Industry should explore more carefully the possibility of large sales in that area. There are difficulties, of course, of service facilities, parts storage in distribution, expensive and unfamiliar sales promotion. Capital is required. But where one firm might fail, several, making complementary products, could well succeed.

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Dust Bowl II

Twenty years ago, a dust cloud from Oklahoma and Texas blew over the American Capitol at Washington to remind the then President of the United States of the human tragedies of the dust bowl. To the Great Plains stretching from Texas and New Mexico, through Colorado and Kansas, President Eisenhower's recent visit has jerked the dry eyes of the American people to the scorching earth and parched rivers—a dryness which has followed the most persistent and widespread drought on record. It has been so severe that the death of trees over 200 years old has been recorded. Of the rain makers from whom so much was expected, and who have headlined water news of the past years, there has been no information.

Over an area of 500,000 square miles the pasture feed supply is under one-third of normal, and over another 300,000 square miles the supply is less than half normal—areas which are increasingly stretching like a cancer westwards into Arizona and Utah, and northwards to the Canadian border. Should high winds arrive during the next few months some 500,000 square miles will certainly "blow." In some parts of Texas the majority of the farmers are queueing for food and over the whole area some 20 million Americans have not experienced the great wave of American prosperity.

It is mother earth's old, old story: a belief in "It can never happen here again," a disregard of the facts of life. Encouraged by the good rains of the war years, high wheat prices brought the plough back into the area to provide relief and persuade a return to grass. Yet without plenty of rain in the spring the ranchers may lose most of their stock. In the United States the conservation of land and water is urgent, as urgent as the desperate shortage of oil in Europe, to which the Texans, lush with oil and no water, appear remarkably indifferent.

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New Lamps for Old

The Electric Lamp Manufacturers' Association is to be wound up at the end of this month. A new council is to rise, Phoenix-like, from its ashes.

E.L.M.A. was criticised in a report by the Monopolies Commission some years ago because it did not represent the whole industry. The new organisation, which may have the title of the Electric Lamp Industry Council, will be more broadly based and will include the one large manufacturer outside the old E.L.M.A. set-up against whom there was a good deal of highly-publicised ill-feeling in E.L.M.A.'s declining years. The new organisation has as its aims the maintenance of quality standards, the encouragement of fair trading, development and standardisation. Membership is open to any company which has a factory licensed by the British Standards Institute. In effect, the founder members of the new Council will be all present lamp manufacturers.

The aims of the new Association are thus common to most trade organisations of its kind. Formerly, the encouragement of fair trading might have been taken to carry a fairly narrow meaning but the new Council comes into existence after the Restrictive Trade Practices Act has become law and the Registrar appointed under the Act has already begun to compile a list of trade associations which are obliged to submit to him information about any restrictive trade practices which may be within their terms of reference. The new electric lamp association is a reminder of the need for industries to organise their common interests and that they may legitimately do so within the meaning of the new Act. Such forms of association are inevitable. They are, like Voltaire's conception of the Diety, something which has to be created if it does not already exist.

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Controversy in Colour

Colour television is already upon us—in two years' time it may be with us. Already there is a campaign to secure the Government's authority to proceed. Last week the Commons and the Lords were treated to a pre-view of what is in store if they say yes. Both the Postmaster General, Mr. Ernest Marples, and the Director-General of the B.B.C., Sir Ian Jacob, were at pains to point out that the demonstration was only a "progress report" on one system and that much development and time would be required before British manufacturers could mass-produce colour tubes and receivers. The "Telecolour" B.B.C. system, as it has been labelled, has the advantage of compatibility, meaning that it could be received equally well in colour or black and white. Mr. Marples, however, would not commit himself on Telecolour's chances of emerging a winner. His television committee, he said, are still studying problems of the different systems.

The demonstrations have, in fact, set forth a first-class row in the industry. The head of one large firm considers that the standards to be adopted have been prejudged, at a time when many technicians feel that the recommendations of the International Consultative Radio Committee (C.C.I.R.) should be seriously considered. The Committee have recommended the 625 line system used in much of Europe for adoption on a world-wide basis. The B.B.C. are thought to

be 405 line minded; they would prefer to use the principle known as frequency interlace, which permits colour information to be transmitted in the same band-width as the normal monochrome transmission. Under this system black and white receivers can receive colour in monochrome and colour receivers can receive original black and white programmes in black and white. The colour receivers were built by Murphy Radio using certain parts imported from the United States, notably the picture tube (made by R.C.A.). Each tube consists of three separate tubes in one envelope with one screen which comprises a series of red, green and blue dot trios over a picture tube face of 225 sq. in. The three electron guns are focused to a point of convergence a short distance behind the dot formation and the beam current of any given gun emphasises its predetermined primary colour. When all three guns have an output equal to 100 per cent. the dot formations are so excited as to add their combined outputs to equal white. This system is an adaptation of current television practice in the United States.

The story does not end here, and promises much lively controversy. British inventiveness is also a contributor. A new colour tube devised by Dr. Dennis Gabor of Imperial College was recently described in a paper to the Television Society as a radical departure from conventional cathode-ray tube construction. The tube is of flat-face construction, that is, a rectangular box of prestressed glass, with three colour guns which are focused and deflected by electrostatic means. It will work at voltages lower than those associated with orthodox systems. Perhaps Mr. Marples is right in dragging his feet—unless the export markets of the world are at stake, in which case why not wait a while to see how the C.C.I.R. recommendations are received ?

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Tubes at Home and Abroad

Stewarts and Lloyds, Limited, are now producing steel at the rate of 1¼ million tons a year, of which the Corby works accounts for almost 1 million tons. During 1956, the tube works of the company were operating at 101 per cent. of rated capacity and in the last financial year (to September 1956) 973,000 tons of tubes were turned out. The company was thus operating at record levels. The output represents an increase of about 15 per cent. on the year before, the company being fortunate in that it was not seriously hampered by the maintenance workers' strike last summer.

Over the last year an effort has been made to deal particularly with the home demand—especially in general-purpose tubes—and the whole of the increase in supplies, apart from tubes made for the oil industry, went into the home market. The delivery of tubes and piping to the oil industry increased by 16 per cent., yet demand is still in excess of the company's capacity to supply it. The company is continuing to expand its steel-making capacity. At Bilston last year, output exceeded 300,000 tons for the first time and a new open-hearth furnace as well as modifications to existing ones has been put in hand. New rolling mills are also to be installed. At the seamless-tube works at Clydesdale a new open-hearth furnace has gone into production and the output of ingots for the tube plant there has been running at record levels. The new rotary forge at Clydesdale has gone into commission and this should increase the supply of casings and line pipe for the oil industry. A second stand for this mill is to be built. An extrusion plant and a new rotary forge are to be built at the Midland works to help meet the continuing high demand for small sizes of seamless tubes, but there is no mention in the company's annual report of the 20,000 tons capacity seamless tube plant which was erected some time ago at Corby.

Broadly, however, it is apparent that the company's traditional division of activity is breaking down. Until a few years ago Stewarts and Lloyds seamless-tube capacity was all located in Scotland and the welded-tube in England. The seamless-tube capacity is now overflowing across the border—one more indication of the continuing high level of activity in the oil industry. The expansion plans for the world petroleum industry and the rapidly growing average depth of oil wells, especially in America, ensures a buoyant market for casings for an indefinite period. The growing number of ambitous long-distance pipeline schemes for oil and natural gas throughout the world is also an indication of the continuing buoyant market for piping.

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Training for the Motor Industry

The fall in the motor industry's output appears to be the main reason why the 1956 index of industrial production failed to show any advance over that for 1955. The industry has had to bear the brunt of special restrictions and taxes, introduced to cover the defects in the economic policies of home and Commonwealth Governments, but it has also suffered setbacks in the expanding European and North American markets, which have called into question some aspects of sales, service, research and development and have drawn attention to the chronic shortage of trained men.

This was given particular attention last week by Mr. Stanley S. Dawes, who said in his Presidential Address to the Institute of the Motor Industry: "Whilst there has been greater activity in training facilities in the manufacturing organisations than in the distributing and servicing sections of the industry, the quality and volume have been completely out of proportion to its requirements and vast productive capacity."

Apart from its craft, trade, student engineering, and commercial apprenticeships, the manufacturing side has its university scholarship schemes and refresher courses. The distributive side now has a mechanics training scheme organised by its National Joint Industrial Council, and there is a four-year residential course sponsored by the Institute of the Motor Industry at the College of Technology at Loughborough, taking the first two years of the automobile diploma course, with the addition of management, law, accountancy, and commercial practice. Now, to produce men for administrative careers in the industry there are to be two new courses. One is a two-year course mainly for overseas students who already have a degree or Higher National Certificate or equivalent, which will embrace part of the third and fourth years of the existing automobile engineering course, with workshop organisation, management, psychology, sales promotion, costing and kindred subjects. The other is a one-year residential course in management and administration.

The view that education is a continuing process beyond craft or technical training is implicit in the foundation of a staff college by the B.M.C. at Haseley Manor, near Warwick. This has now been operating with considerable success for some months under the direction of a former principal of the Birmingham College of Technology. The five-day course takes 24 members, who are drawn from all levels, from apprentices to management, to study and discuss economics, sales and service, design and manufacture, budget and cost control, automation and electronics.

The college seems to be achieving its declared objectives: improvement in the quality of management and supervision, strengthening of personal relationships, development of social responsibility, and extending knowledge of latest methods in the technical and commercial fields.

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Civil Airport Losses

In a special report issued towards the end of last month the Select Committee on Estimates strongly criticised the Minister of Transport and Civil Aviation for apparent reluctance to take adequate steps to reduce increasing losses in operating the Ministry's airports, and recommended the House of Commons in Committee of Supply to give urgent consideration to the vote for civil aviation. The first report on this subject by the Select Committee, published a little over a year ago, ran to 300 pages and provided the public with the first detailed facts on how much airports cost to run.

The report pointed out that the Ministry, even for its own internal purposes, does not record more than the day-to-day running expenses and gross capital outlay on the 30 civil airports under its control. Operating losses in the year 1954/55 amounted to about £1·7 million but, allowing for interest on capital and for the cost of administration, the Committee estimated that total losses were about £6 million a year. In their latest report they state that these figures have increased to nearly £1·9 million and £7 million respectively, in spite of an increase of about 18 per cent. in passenger traffic and about 39 per cent. in freight. The operating losses alone represent a subsidy of about 8*s*. a passenger and the total loss would represent about 30*s*. per passenger.

The main source of operating income at airports is, of course, the landing fees paid by the air transport operators. These are based on 5 per cent. of the revenue that would be earned by each specific type of aircraft assuming that it flew two-thirds full. The problem is to some extent an international one in that air transport operators claim that their fares are subject to international agreement. If, therefore, landing fees are substantially increased they are unable to cover this increase by raising fares. They also argue that, in the particular case of London Airport, the fees are already the highest in the world and if they are increased there will be a tendency to by-pass London.

With the introduction of high-speed jet aircraft the cost of providing the necessary airport facilities and services must necessarily rise still further; the Executive of the International Civil Aviation Organisation drew attention last year to the fact that the facilities in many areas fall short of operational requirements. This has led to a proposal that I.C.A.O. should be instructed by the Governments concerned to produce a plan for the internationalisation of airports.

Such a proposal seems unlikely to be implemented at present but there is undoubtedly a strong case that the cost of operation of airports should be taken into account in fixing the level of fares. The Minister of Transport announced in the House of Commons last week that he was studying the report of the International Conference on Airport Charges and hopes shortly to be in a position to announce a scheme for increased landing fees.

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Fuel Oil Supplies

In spite of the pledge given by the Minister of Power at the end of last week that there would be no further cut in fuel oil supplies to industry before the end of March, it is clear that if the rehabilitation of the Suez Canal is delayed, a critical situation must develop. For the first three months since the closing of the Canal, the O.E.E.C. Oil Committee's Petroleum Emergency Group has estimated the total availability of oil in the three main groups to be motor spirit 75 per cent., Diesel oil 85 per cent., and fuel oil just over 60 per cent. of normal needs. In the United Kingdom it has been necessary to draw extensively on stocks, in spite of consumption being materially reduced by savings of about 80 per cent. by the Central Electricity Authority, of 25 per cent. in central heating, of 15 per cent. in the iron and steel industry by the use of alternative fuels and of 10 per cent. in other branches of industry.

This country was fortunate in that, at the beginning of the emergency, stocks of fuel oil

were very much higher than the average for Europe. Moreover, although the United Kingdom is the largest individual user of fuel oil, the proportion of total energy requirements supplied in this form, at 3 per cent., is lower than that of most European countries with the exception of Germany. The effect of the fuel oil shortage is most severe in Italy, Sweden and Denmark, where fuel oil forms nearly 20 per cent. of total energy requirements. It is estimated that, by mid-February, the level of stocks over Western Europe as a whole will have fallen to only two weeks' restricted consumption.

The present position is aggravated by the fact that the first three months of the year are the period of heaviest demand in the United States, and as a result fuel oil shipments from there have virtually ceased. The fact that it has been possible to avoid a further cut in supplies to British industry before the end of March holds out hopes that by the time stocks are exhausted it may be possible to obtain substantially increased supplies from the United States. In view of the gravity of the fuel oil situation as a whole the United States Administration has announced that under certain conditions a proportion of the United States military reserve stocks will be made available for export to Europe. Because of the greater seriousness of the position in a number of European countries, however, the United Kingdom is unlikely to derive much benefit from this source.

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The Third Force

At long last someone has moved to placate Lord Beaverbrook and draw him and his not-to-be-laughed-at followers into the Macmillan-Thorneycroft fold. The Third Force made its appearance in *The Times* and elsewhere on January 30. The movement will, for the present at any rate, confine itself to a Press advertising campaign intended "to mobilise, arouse and awaken public opinion." The proposals are straightforward enough: let us have a common market group and weld into it "the vast, rich and potentially powerful territories of Africa and Australasia." This will produce a grouping of resources, strategic advantages and political know-how which neither America nor Russia can match. So the Third Force will be the First Force.

The difficulties now facing the politicians who lead the way to the establishment of a common market in a limited area in a limited field of industry should be enough to convince even the most innocent that the establishment of a "Third Force" would raise problems many times greater. What of the Commonwealth? Canada, India, Ceylon, Burma and others are not mentioned. What of hostile regions or régimes, as in both North and South Africa? What of the competitive rather than complementary economics of Australasia and Western Europe in all primary produce but wool? Future historians may well say that the decline of the Commonwealth arose from Britain's failure to decide between Europe and the Commonwealth countries. Some of these difficulties have now to be faced in determining precisely how far and how fast Britain will enter a free-trade area in Europe. But could mobilised public opinion help in what is primarily an administrative approach to problems with roots centuries deep? The view that political integration follows economic integration is more convincing.

Meanwhile the treaties of the common market and Euratom made slow but steady progress at the Brussels meeting of the six Messina countries. Mr. Nigel Birch, Economic Secretary to the Treasury, in a speech at Leeds, and Sir David Eccles, President of the Board of Trade, in the House have again made clear the Government's policy—that "failure to associate would be likely to involve serious consequences to our position as an exporting country."

Trade and Politics

A number of chairmen referred to the impact of the Middle East crisis and its off-shoots petrol rationing and oil shortage upon recent results. Mr. A. G. Stewart, chairman of Stewarts and Lloyds Limited, states categorically that "the oil shortage has not interfered with our production or sales up to date." Demand from the oil industry continues at a very high level, orders coming in at a rate which exceeds the company's capacity to supply. On the whole, Mr. Stewart's analysis of the position would appear thoroughly to justify his confidence in the long-term future and in his company's policy of expansion.

Two companies, Associated Engineering Holdings Limited and Qualcast Limited, feel the effects of the crisis in a more acute form. Mr. V. Jobson, chairman of Qualcast, found it necessary to issue a letter to all shareholders and employees explaining why his stated expectation that all the group's foundries would be working by the end of the year had not materialised: "our foundries are largely interested in the motor and refrigerator trades, and where we had based our calculations upon the viewpoint of customers, unfortunately these have not developed to the extent anticipated, and the turnover of our group shows a considerable cut-back." Mr. Jobson writes of this as a challenge and a need to "fight aggressively for sales."

Associated Engineering Holdings, whose most important customer is the motor industry (40 per cent. of turnover) found that the decline which started in mid-1956 continued until the end of the year and is likely to be accentuated by the rationing of petrol and the reduction of fuel oil supplies. Mr. A. H. Jarrard, who retired from the chairmanship and the board at the meeting, commented that non-vehicle business was good, particularly turbine-blade manufacture for civilian aircraft and expressed his confidence that the group "face a prospect of considerable expansion in the long-term." Meanwhile rising costs, of materials, labour and fuels, are eating into profit margins and are a continual threat to the group's prosperity. The question of how far this recession will go and when it will end is vital to general confidence. Have we not had enough disinflation?

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Electronics to the Fore

Two companies, one large and one small but both expanding rapidly in allied fields, report a year of great activity. The British Tabulating Machine Company, Limited, give interesting facts and figures concerning their progress. Their chairman, Sir Cecil M. Weir, announces that, at September, 1956, the capital employed by the company amounted to approximately £10 million, about 2½ times as much per employee as pre-war, and comments that "this increase is some measure of the combined effect of inflation and mechanisation which has taken place since 1939, that is in 17 years." The policy of the company is strongly expansionist; three new factories have been taken over or are being planned to meet anticipated demand for electro-mechanical and electronic equipment. Production of the latter has doubled in the last year. Two research and development companies have been set up, one in the United States in conjunction with the laboratory for electronics in Boston, under the name of International Computers Corporation, and the other in the United Kingdom in conjunction with the General Electric Company, Limited, under the name of Computer Developments. Sir Cecil found the general outlook "encouraging" with good new products and full order books. The development of computers for applications "in the fields of production planning and control in the factory" is the next step and the goal of the new research companies.

The other company, much smaller but no less lively, is the Solartron Electronic Group Limited. They have issued an illustrated annual review of the year's progress which is full of information about themselves, their products, their markets and what's cooking. The opening sentence is worth quoting: "In Solartron the habit of looking forward is so deeply ingrained that the annual task of looking back is no easy one . . ." Increasing fixed assets by one half, to £650,000; doubling sales and nearly doubling productive floor space, is no small achievement. The products—servo test equipment, oscilloscopes, measuring instruments, stabilised power supply equipment, high-speed check-weighers, radar simulators and data-processing equipment—indicate a policy of diversification which provides a comfortably wide spread over industry. The 1956 sales analysis shows that though defence took 27·5 per cent. of the group's output, no single industry accounted for as much as one fifth. Telecommunications and cables (19 per cent.) were the largest customers, followed by manufacturers of electrical equipment (14 per cent.), educational and research establishments (9·2 per cent.), electronic equipment and components (8·4 per cent.), aircraft, radar and navigational aids (7·2 per cent.) and several others. There would appear to be no limit to the rate at which the electronic and electro-mechanical industries will expand. But it would be better for the country if the expansion were even more rapid.

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Obituary

SIR JOHN CRAIG, C.B.E.

The news of the death of Sir John Craig, C.B.E., D.L., LL.D., in his 83rd year, at his home Cambusnethan Priory, Wishaw, Lanarkshire, on February 1, will be received with regret by engineers and metallurgists in many parts of the world. A highly esteemed and respected figure throughout the iron and steel industry, Sir John retired only last year, on January 20, 1956, from the positions of chairman and joint managing director of Colvilles Limited, after occupying the post of chairman for nearly 40 years.

The son and the grandson of iron workers, John Craig was born at Clydesdale, New Stevenston, Lanarkshire, on December 11, 1874, and, in August, 1888, entered the works of David Colville and Sons, then situated in Crosshill-street, Motherwell, as an office boy at 5*s*. a week. In addition to helping to keep the books he gained a valuable insight into the manufacture of iron and steel as it was then carried on. In 1895, when only 21, he succeeded John Colville, David Colville's eldest son, who had entered Parliament, as representative of the firm, which by then had been formed into a limited company, at the Royal Exchange in Glasgow. After John Colville's early death in 1901, a heavier weight of responsibility fell on his two brothers, Archibald, who succeeded him as chairman, and David. John Craig was so diligent in helping to shoulder the burden that he was appointed a director in 1910 and when the two brothers, David and Archibald Colville, died six years later, he was elected chairman at the early age of 42. To him fell the main responsibility for all subsequent developments.

Beginning in 1915, by the acquisition and merging of interests and the creation of new works, the firm of David Colville and Sons, Limited, eventually became Colvilles Limited, which, during the war of 1939-1945, were responsible for some 85 per cent. of the iron and steel produced in Scotland. Created a C.B.E. in 1918, John Craig was knighted in 1943 and was awarded an honorary Doctorate of Laws by the University of Glasgow in 1951, its quincentenary year. Sir John was an early President of the National Federation of Iron and Steel Manufacturers, which he did much to found, and he served as President of the Iron and Steel Institute from 1940 to 1942. He was elected an honorary member of the Institute in 1956. Sir John was also a Deputy Lieutenant for the County of Lanarkshire.

WORK STUDY EXTENDED TO NON-REPETITIVE TASKS

A most unlikely application for work study, and one that had been considered impracticable, is the permanent way maintenance that has to be carried out by the railways. Not only is the work, generally speaking, non-repetitive, but it is also subject to widely varying conditions and contingencies. However, the continued drift of experienced platelayers into more remunerative, though less responsible positions in industry, made the introduction of some form of labour control and incentive scheme a matter of necessity. The introduction of such a scheme and its considerable success has been described in a paper presented by Mr. D. D. T. Pescod and Mr. J. C. F. Cameron to the Institution of Civil Engineers.*

The authors reported that the scheme, started nearly two years ago, now successfully covered some 13 permanent way sections in the Purley district and the ultimate justification for its extension to the whole Southern Region, British Railways, had been the financial benefit that accrued to the management as a result of the application of its principles.

The scope of the study covered had been immense. Outputs, methods of work, methods of organisation, limits of authority and additional features such as train interruption time all had to be recorded and examined. New manning formulae had been evolved taking into account length and complexity of track conditions, traffic density, etc., each factor being studied systematically.

The level of productivity before the investigation was generally between 40 and 45 A.M.'s per hour among permanent way length gangs. The basic work unit used was the "Allowed Minute," or A.M. It consisted of a fraction of a minute for work and a fraction for rest, the rest fraction increasing with the arduousness of the work. Thus, by relating the output in A.M.'s to imput in man-hours the labour productivity of a single operator or of a gang may be determined.

A 50 per cent. increase in output had been planned in the first 12 to 18 months and, on this basis, the manning required to carry out the work of a permanent way section under incentive conditions was taken as the standard manning under hourly rated conditions reduced by approximately 30 per cent., the manning being set at an operator performance of 70 A.M.'s per hour. The only exception found to this reduction of manpower had been in the manning allowance for point oiling and "look-out" duties. Work measurement had shown here a higher manning to be necessary. The methods of maintenance were examined and in many cases simplified, but it had been proved that by far the greatest saving could be realised by a study not so much of the operations themselves but of the organisation of the ganger or chargehand who carried them out.

After the examination of an operation (usually based on 20 or more studies) the A.M. value for that operation had been established. The observed times from the studies were first "normalised," i.e., modified according to the operators' rate of working. The "normalised" time was given by the formula $\frac{\text{rating}}{60} \times$ observed time. This followed the British Railways practice of the 60-80 scale of rating. Slow work was given a 40 rating, normal speed a 60 rating and brisk work an 80 rating. The maximum speed consistent with quality and safety had been fixed at a 100 rating.

* "Work Study and Its Applications to Railway Civil Engineering Maintenance," by D. D. T.Pescod, deputy assistant (productivity and planning) to the chief civil engineer, British Railways (Southern Region), and J. C. F. Cameron, assistant to district engineer, Purley (planning and work study), British Railways (Southern Region). Railway Paper No. 64, Institution of Civil Engineers, submitted for discussion on January 10, 1957.

The "normalised" times had then been converted to A. M.'s on a "set up" sheet on which were specified all the elements of an operation. To the "normalised" times were added the fractions of rest called "compensating relaxations" based on the industrially accepted scale of factors for dirt, noise, weight of tools, etc. Additional allowances were calculated for especially difficult conditions and to cover features like "starting and stopping" (40 A.M.'s per man per day) and changing over jobs (2 A.M.'s per man per occasion).

Work specification sheets were written by the work-study assistant together with the allowed-time calculations, and both were issued to the gangs. Each ganger had been carefully instructed how to complete a specially designed and standardised work return. This showed clearly all the facts relating to his work from which his output and input could be analysed and his productivity determined. Provision was made on the work return for the separate assessment of productive time, which consisted of "measured hours" and "unmeasured hours," and non-productive time which consisted of "ineffective time" and "indirect hours."

Assessment of the quality of work and the actual lengths covered was done by the supervisory staff who in turn produced a control sheet recording diagrammatically the work done.

Each operator's bonus was calculated daily from the control data, but since an operator might be working many miles from the office he was only notified of his bonus once a week and paid the bonus during the following week. Individual bonuses were calculated on a separate rate for each grade, related to the hourly rate and such that, at the 80 performance, the bonus equalled one-third of the rate. A starting level of 40 A.M.'s was subtracted from the total and the bonus calculated on the remainder using a multiplier of the rate per 10 A.M.'s.

A very important feature of a scheme of this scale was the training and labour consultation that had preceded its introduction. The work-study staff who were recruited from the Chief Engineer's Department were trained for three months on both the theoretical and practical aspects of the subject and had subsequently worked under a senior work study engineer.

The inspectorate staff were given appreciation courses in work-study and special instruction in the preparation of the control charts. Enthusiastic co-operation of a well-informed body of supervisors was considered to be essential for carrying the men along. Finally the men were given a full explanation of the scheme and its implications through the normal trade union channels and joint consultation. In addition, the gangs were separately visited by a work study assistant and inspector who were able to clear up their remaining doubts.

BASIC WORK STUDY

In a complementary paper* entitled "Work Study," presented to the Permanent Way Institution by Mr. R. W. Bailey, the author commented that the main responsibility for improvement in industry had to be accepted by management and not by labour. Management devoted too little time to the task of "sitting and thinking" which could profitably lead to the elimination of obstructions to production. He went on to outline the eight basic steps of work study which he listed as follows.

1. Select the job to be examined first as indicated by bottle-necks, delays in programme, labour problems, etc.
2. Record the actual method of production accurately and in detail.
3. Examine each phase of the job asking of each the questions What? Where? Why? Who? When? and How?
4. Develop a new method incorporating the best features of the existing method. Then re-examine the new method.
5. Define precisely and clearly the new method as a basis of operation instructions and for future re-examination.
6. Measure rate of production under new method.
7. Instal the new method, bearing the question of human relations constantly in mind.
8. Maintain the new method in operation and safeguard from departure from the new method by periodic inspection and reference to the operation instructions.

These were the basic steps used by all work study engineers. Use was also made of devices such as the process chart and multiple activity chart, which were nothing more complicated than the graphical representation of individual actions in a process to a scale of time. Finally, a strong word of caution was sounded on the importance of consulting and informing labour throughout the study. Work study was considered by many experts to consist of 25 per cent. method study and 75 per cent. human relations study. The study of human relations was again clearly the responsibility of the management.

* "Work Study," by R. W. Bailey, assistant to general manager (productivity and work study), London Midland Region. Read and discussed at the Permanent Way Institution on January 9, 1957.

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B.E.A. TO EXPAND MAINTENANCE FACILITIES

British European Airways are to extend their engineering base at London Airport in order to cope with the maintenance of the new fleet of Vickers Viscount 800 airliners which the Corporation has ordered. Delivery of these new aircraft has already started and, if all the options are taken up by 1959, B.E.A., will have up to 80 Viscounts in service. They will be followed by 20 Vickers Vanguards.

To provide the necessary maintenance facilities for the greatly expanded fleet, the total floor area of the hangars and workshops will have to be increased from 458,000 sq. ft. to 958,000 sq. ft., and there are to be ten new hangar bays which will be larger and higher than those in use at present. The new building has been planned on four principles: maximum utilisation of floor area, the use of natural lighting wherever possible, maximum flexibility of production space, and making the new building complementary to the old.

An outstanding feature of the new hangar and workshops building will be a central basement which will provide ready access for the delivery of goods and components to the workshops as well as easy movement of the staff. The workshops will occupy a completely unrestricted area between the hangars and, as they will extend along the full length of the building, they will permit a working flexible layout.

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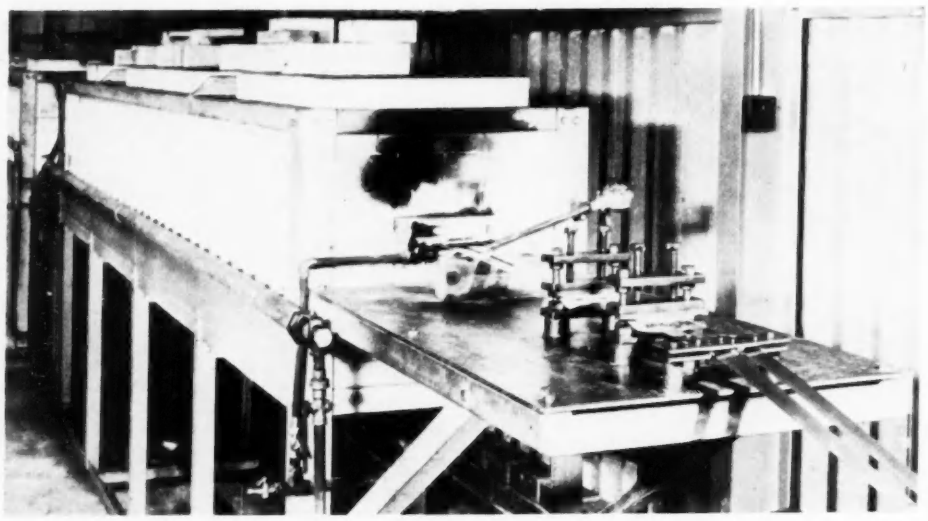
EARLY ELECTRICAL GEAR

Company Museum Inaugurated

George Ellison, Limited, Perry Barr, Birmingham, have recently inaugurated an "Obsolete Gear Campaign," the object of which is to obtain a good specimen of each type of gear supplied by them in the early years of their existence and thus to build up a museum which should have the makings of great historic interest.

The latest acquisition to this collection is an air-cooled stator-rotor starter. It dates back to 1908, only two years after the company was founded; it is still being used for controlling a slip-ring motor in the Wolverhampton factory of the Chillington Tool Company, Limited. It is, in fact, the earliest of the Ellison models so far discovered, displacing the previous oldest, a 47-year-old star-delta starter used in the Huddersfield textile factory of George Beaumont and Sons, Limited.

More models are still required to ensure the completeness of the museum and donors would have their old equipment replaced free by modern gear.



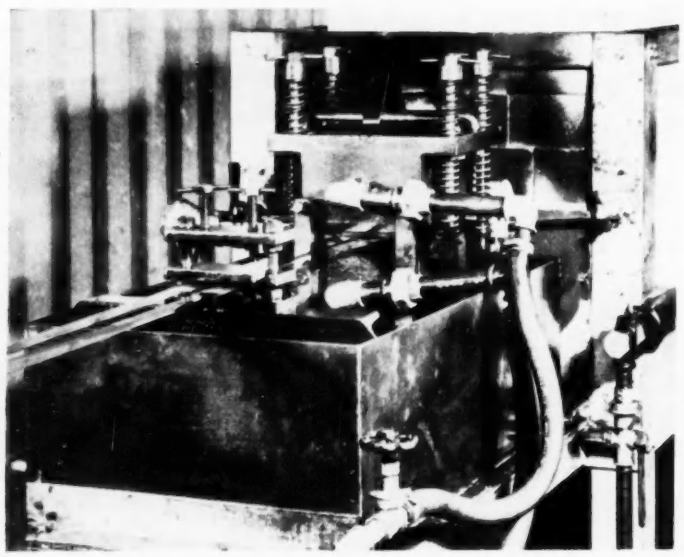


Fig. 1 (above) Entry to 12 ft. long gas heated and purged hardening furnace. The steel strip is first passed through felt wiping pads which remove surplus oil and grit.

Fig. 2 (left) Oil-quenching system at exit end of hardening furnace; in this a stream of oil, under pressure, is projected on to both top and bottom surfaces of the strip over a length of 8 in. The strip then enters the tempering furnace on the left.

HARDENING AND TEMPERING STEEL STRIP

CONTINUOUS OPERATION WITH TWO FURNACES

Two furnaces for the hardening and tempering of steel strip, designed for their own use by G. F. Homer (Redditch), Limited, steel-strip producers, were built in November, 1954, and have been in operation since that time. The furnaces, for which the Worcestershire-Herefordshire Division of the West Midlands Gas Board supplied burners, governors and controls, are described in a report (No. 616/56) of the Industrial Gas Development Committee of the Gas Council, 1 Grosvenor-place, London, S.W.1.

The heat-treatment plant consists of two similar furnace settings, each 12 ft. in length, with a longitudinal tunnel 2½ in. high and 6½ in. wide passing through the centre. The tunnel is constructed of standard firebrick sections and is a complete muffle. The muffle is surrounded by insulating refractory and the overall measurements of the tunnel are 24 in. wide and 22½ in. high.

The hardening furnace, a general view of which is shown in Fig. 1, is heated by four 1½ in. aerated burners each with fifteen ⅜ in. British Standard pipe nozzles extending through the furnace side walls. Injectors supplied by Amal Limited, Witton, Birmingham, 6, are employed to give a maximum gas rate, for the four burners, of 480 cub. ft. per hour at 3 in. water-gauge pressure. Secondary air is supplied to each flame through the apertures in the furnace walls accommodating the burner nozzles.

Town gas is also used for purging the two muffles of the installation and is admitted at the inlet end of each of them by means of a ¼ in. B.S. pipe. The steel strip to be hardened is fed from a reel and passes through felt wiping pads which remove surplus oil and grit. It then enters the muffle at a speed which can be varied between approximately 3½ ft. and 25 ft. per minute. The strip passes through the hardening section operating at a temperature of up to 950 deg. C., is heated to the required hardening temperature and is quenched immediately upon exit. The method of quenching is to project a stream of oil under pressure on to both the upper and lower surfaces of the strip over a length of 8 in. The quenching system is seen in Fig. 2.

The second (tempering) furnace setting is similar in design and dimensions to the first (hardening) setting and operating at a temperature within the range 350 deg. to 600 deg. C. The burners are fitted with 1 in. B.S.P. injectors supplied by the Aeromatic Company, Limited, Eskdale Road Trading Estate, Uxbridge, Middlesex, and have a total maximum gas rate of 260 cub. ft. per hour at 2·5 in. water-gauge pressure. Following the tempering operation, the strip passes around three rollers arranged in line, with the middle roller at a lower level. The rollers draw the strip through the settings and it is then wound on to another reel. Both the reel and the rollers are driven by a variable-speed electric motor.

Gas-pressure governors are fitted to both the hardening and the tempering sections. The first half of each of the two furnace settings is treated as a pre-heating zone and is controlled by a quadrant cock. The second half of the furnace setting is equipped, in each case, with temperature-indicating controllers working in conjunction with solenoid valves and four thermocouples are fitted, two in the hardening section and two in the tempering section.

The largest size of steel strip which can be treated is 3¼ in. wide by $\frac{1}{16}$ in. thick and the maximum weight of work capable of being handled in one hour is 120 lb.

In two tests involving the heat-treatment of (*a*) three steel strips, dealt with simultaneously, each strip measuring ½ in. by 0·008 in., the total weight being 300 lb., and (*b*) two strips treated simultaneously, each strip measuring 1⅛ in. by 0·02 in., and weighing a total of 550 lb., the hardening temperature of the strip was 850 deg. C. and the tempering temperature 410 deg. C. Incidentally, the temperature of the hardening furnace was 900 deg. C. and that of the tempering furnace 460 deg. C. Throughout, the calorific value of the gas was 450 B.Th.U. per cub. ft. In test (*a*) the total gas consumption, including that consumed in purging, was 2,125 cub. ft. The average gas consumption per hour was 425 cub. ft., and per lb. of steel, 7·08 cub. ft. In test (*b*) the total gas consumption was 2,250 cub. ft. The average gas consumption per hour was 450 cub. ft., and per lb. of steel, 4·09 cub. ft.

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COUPLING TUBES

Simple Joints for High Pressures

A relatively simple but highly efficient means of coupling steel or other metal pipes and tubes has been developed by Mr. R. J. Mitchell, a director of Allied Art Industries Limited, 71-75 Barrack-road, Leeds, 7. It is pointed out that tubing of all gauges and bore sizes from ⅛ in. to 2½ in. and of all metals and alloys in engineering use may be coupled by this method, and that a special application for polythene tubing has been fully tested and approved for use for cold-water services above ground.

The first operation in carrying out the tube assembly is shown in Fig. 1. The steel tube seen on the left is drifted by the simple tool shown horizontally in the illustration. The result of the drifting operation is shown on the right of Fig. 1 and it will be noted that the conical flare imparted to the tube is of small angle and does not endanger the tube by splitting. The conical tube end provides a mounting for inner and outer conical reinforcing sleeves. These are shown in position on the ends of two

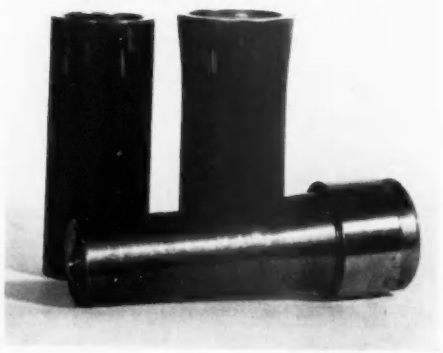

Fig. 1 The tube ends are first drifted with the tool shown to form a small-angle conical flare which provides a mounting for inner and outer reinforcing sleeves.

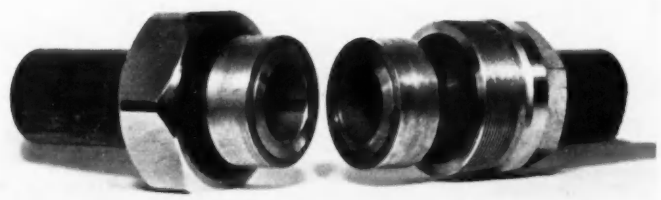

Fig. 2 The inner and outer reinforcing sleeves have been fitted on the tube ends and the coupling is ready for the insertion of a sealing ring, or washer. Final assembly is accomplished by screwing up the outer connecting rings.

tubes in Fig. 2. The inner sleeves fit so snugly in the interior of the tubes that they are barely discernible, but the outer sleeves, which are quite obvious, provide shoulders that bear against concentric flanges in the screwed outer connecting rings, also shown in Fig. 2. Before final assembly by the screwing up of the outer connecting rings a sealing ring is placed between the ends of the tubes; this sealing ring, or washer, may be a proprietary component or may consist of neoprene, fibre or nylon. For the most arduous conditions, however, a sealing ring incorporating an outer metal concentric guard ring is adopted in order to prevent the crushing of the sealing ring.

We are informed that the M-A tube coupling, as it is termed, has been tested under extreme conditions of pressure and hydraulic shock load without a trace of leakage. In these tests the couplings were exposed to 280,000 cycles of rapidly pulsating hydraulic loading at pressures ranging from zero to 7,000 lb. per sq. in. every two seconds, followed by an additional run of 5 hours at 9,000 lb. per sq. in.

An important advantage of the coupling is that any section of a complex tube circuit may be removed in a few seconds without disturbing adjacent sections of the pipeline. This advantage is of particular value on heavy-gauge pipelines in confined spaces.

INJECTION MOULDING MACHINE

UTENSILS MADE FROM GRANULATED PLASTICS

Following the successful completion of extended tests under both laboratory and intensive production conditions, arrangements have now been completed whereby H.P.M. hydraulic injection moulding machines, for the production of utensils from granulated plastics, will be manufactured in this country. The machines are produced in the United States by the Hydraulic Press Company, Mount Giliad, Ohio, and, in association with Wickman Limited, Factored Machine-Tool Division, Fletchamstead Highway, Coventry, a new department has been formed at the works of Cravens Limited, Darnall, Sheffield 9, where the construction of the machines has commenced under modern production conditions. The range of machines in course of manufacture include the 12, 20 and 48 oz. machines, these being the capacities of the machines expressed as the weights of polystyrene moulded per cycle of operations. The corresponding locking pressure or mould locking force of each of these three machines is 268, 360 and 715 tons. We are informed that larger machines of up to 400 oz. capacity can be constructed to clients' requirements.

A demonstration of a British-made 400-H-20 machine, the plastics moulded weight capacity of which is 20 oz., was held recently at the Cravens Limited Darnall works. A general view of the machine, which operates on a semi-automatic cycle, is shown in Fig. 1, while Fig. 2 shows the safety gate open and the operator removing a finished polythene basin from the female mould. As will be seen, the machine is of the straight-line horizontal type with platens at a convenient height and providing ample " daylight " for the removal of finished articles and for the production of deep components.

The hydraulic circuit, incorporating manifold mounted valves situated in accessible positions at the rear of the clamp closing and injection cylinders, eliminates extensive pipe work and also leaks and other possible sources of trouble. The overhead oil tank, seen on the left in Fig. 1, is situated above the clamp closing cylinder of the machine, thus preventing cavitation and also the possibility of the contamination of the oil with water, plastics material and foreign matter. Oil-level and temperature indicators are fitted in prominent positions.

As may be seen in Fig. 2, the die platens are of ample proportions, measuring 36 in. by 42 in., and are drilled and tapped in accordance with the recommendations of the British Plastics Federation. The maximum die space of this machine measures 40 in., or 34 in. with a spacer and the minimum 15 in., or 9 in. with a spacer.

Dry granulated plastics material is fed into the machine by way of the hopper seen on the right in Fig. 1. This has a capacity of 100 lb. and it allows the plastic to run into an accurate weighing and feeding unit seen underneath the hopper in Fig. 1. This apparatus has been designed and built by Southall and Smith Limited, Hockley, Birmingham, 19. The injection unit of the machine is mounted on ways and is operated by a single hydraulic cylinder. At the end of an injection reverse stroke, a weighed quantity of the plastic falls in front of the plunger and the injection ram moves it forward into the heating chamber. This is equipped with three electrically heated zones, each controlled by a pyrometer supplied by Ether Limited, Erdington, Birmingham, 24. In the heating zones the granulated material gradually becomes soft and workable or is " plasticised," as it is termed. Finally, the injection ram forces the plastic through the heating chamber and into the die; after a predetermined interval the injection plunger is moved back, the die platens separated, and the safety gate, which is electrically and hydraulically interlocked with the operating sequence, is opened. The finished plastics component is then removed as shown in Fig. 2. The completely unobstructed opening beneath the mould mounting space facilitates the fitting of moulds into place and also provides the necessary space for chutes or other unloading facilities should they be required.

The overall length of the machine is 20 ft. 6½ in., its width is 5 ft. 7 in., and its weight, 17½ tons.

Fig. 2 Removal of a finished basin from the female mould at the close of a cycle of operations. The ample " daylight " afforded when the machine is opened is apparent.

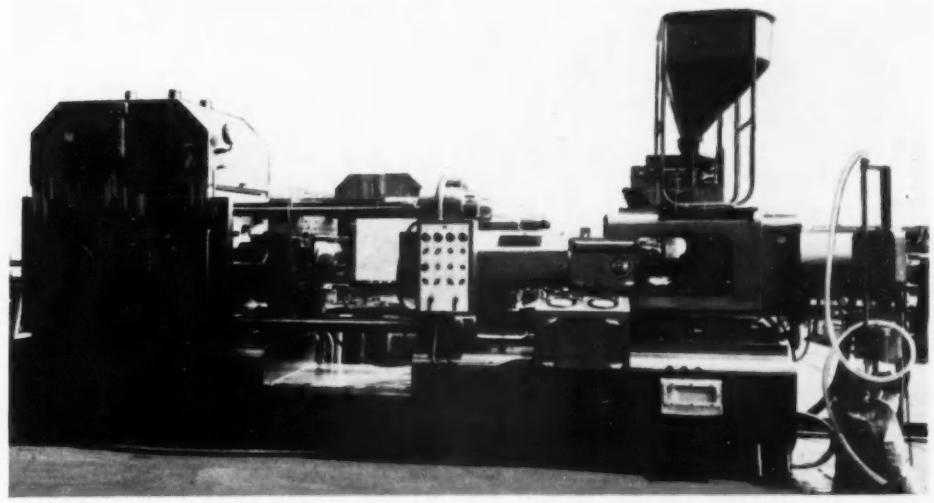

Fig. 1 Front view of British-made H.P.M. hydraulic injection moulding machine used for producing components from granulated plastics. The hopper feeding the raw material into the machine is seen above it on the right. On the left is the overhead oil tank above the clamp closing cylinder.

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BELGIAN JOURNAL CENTENARY

The Association des Ingénieurs sortis de l'Ecole de Liége (A.I.Lg.), itself founded in 1847, this year celebrates the centenary of its scientific organ, *La Revue Universelle des Mines*, which is the oldest Belgian technical periodical in existence. To mark the centenary, a conference on the theme " Scientific Research and Industry " is being organised to take place on May 6, 7 and 8, 1957. The work of the conference will be divided up into eight sections, dealing respectively with coal, chemistry, electricity, nuclear energy, civil engineering, ores and metals, iron and steel manufacture, and mechanical engineering. Further particulars are obtainable from the general secretary of the Association, 22 Rue Forgeur, Liége, Belgium.

HOBBING GEARS AUTOMATICALLY

ADAPTABLE TRANSFER LINE

When Churchill Gear Machines, Limited, Scotswood-road, Newcastle-upon-Tyne, put their Mk. IV Churchill-Cleveland Rigidhobber on the market about two years ago, it was designed not only to provide a fully-automatic hobbing cycle, but also to be suitable for conversion to semi-automatic or fully-automatic loading. Allowance for this conversion was made in the electric and hydraulic equipment, and the conversion can be carried out quite easily, without affecting the operation of the machine under manual control if required. Semi-automatic operation, with the component positioned by hand but clamped and machined in an automatic cycle, was the first step, and this was soon followed by the introduction of tube loaders, which are in extensive use for disc-type gear blanks up to about 2¾ in. in diameter.

The machine is now available with a fully-automatic loading and unloading arm, which grips the component, lifts it from a conveyor or loading platform, swings it into position above the work-holding fixture, lowers it on to the fixture and releases it. These movements are controlled in sequence with the machine and conveyor indexing cycles, and it is possible to handle almost any type of gear with one standard transfer arm. The gripping fingers on the arm are easily interchangeable to deal with various diameter of gears and shafts. When the size of the component is too great for handling with the fingers working in a horizontal plane, they are turned through 90 deg. to engage on the component faces. Hydraulic power from the built-in hydraulic system on the machine is used to operate the transfer arm, which is swung by a vane-type piston and has an independent double-acting piston for opening and closing the gripping fingers.

SEQUENCE OPERATION WITH FULL INTERLOCKING

The machine can be used in various ways, the simplest of the automatic-cycle methods being for the hobbing of a single gear from blanks which are brought to it by conveyor, the cut gears being removed by the same means. A machine equipped with a simple manually loaded and unloaded conveyor is shown in Fig. 1, on which the push-button controls of the machine are also clearly visible. When the machine has been set up with the aid of these controls, in the normal manner, as it would be for manual operation, it is ready for use on the automatic cycle. With the hydraulic pump driving motor running, the conveyor loaded with blanks, and the loader in the pick-up position, with its fingers open ready to receive a blank, it is only necessary to use a " start " push-button to set the automatic cycle in operation. The machine and conveyor then run as a unit, with sequence operation and full interlocking.

When the " start " button is pressed, a solenoid opens a hydraulic valve which allows a piston connected to the conveyor to carry out the conveyor indexing motion. The transfer arm then grips the component, lifts it, and swings it into line above the hobbing fixture. Meanwhile, the conveyor piston returns to its original position. The transfer arm next lowers the component on to the fixture, the tailstock moving down to hold the component before the gripping fingers are released.

As soon as the component is clamped the automatic hobbing cycle begins, the hob slide moving in at rapid traverse, and the hob rotates. Vertical feed commences, and the hob slide continues its forward movement, but now at feed rate. This movement continues until the hob slide comes up against a dead stop, the vertical feed continuing until the gear is cut. The hob rotation then ceases, the hob slide moves out at rapid traverse and the work head goes back to its starting position, also at rapid traverse. While this is happening the tailstock retracts, and the transfer arm grips the component, lifts it and swings it into line with the conveyor. Finally the arm lowers the component on to the conveyor, which then indexes, and the cycle re-commences. Removal of the component is shown in Fig. 2, where the transfer arm is swinging a hobbed gear out before lowering it on to the conveyor.

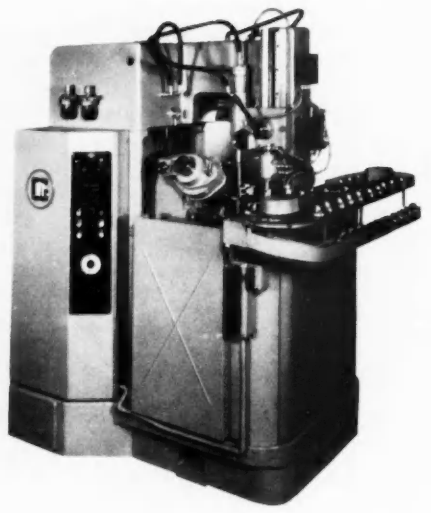


Fig. 1 A conveyor and automatic transfer arm enable the Churchill-Cleveland hobbing machine to be run on a fully automatic cycle.

When the conveyor needs re-loading the machine stops automatically at the end of its cycle when two components remain to be cut. A flashing red light on the top of the machine signals the fact that it needs attention. If it should happen that the two uncut components are the last of a batch, it is only necessary to press the " start " button, and the machine will operate non-continuously, that is, it will go through a load, hob and unload cycle, and then stop once more. A switch on the main control panel enables the machine to be stopped at the end of a cycle at any time, and there is also an emergency stop button which overrides all other controls, causes the hob slide to move out, and brings the machine to rest.

CUTTING SEVERAL GEARS ON ONE SHAFT

A machine as illustrated in Fig. 1 would only be capable of cutting one gear, and while this is all that is necessary for many purposes, provision has to be made for dealing with two or more gears on a single shaft, such as are used in automotive gearboxes. A typical example of this type of component has two helical gears, of 43 and 36 teeth respectively, and one spur gear of 17 teeth on a forged steel shaft 9⅜ in. long. Three hobbing machines are used in line for this component, one machine dealing with each gear, and all three being fully interlocked. The conveyor indexing waits for all three machines, and can only operate when they are ready. This means, of course, that the two machines cutting the smaller gears have to wait for the machine dealing with the larger one.

Using a hob speed of 250 r.p.m., a vertical feed of 0·040 in. per revolution of work, and climb cutting, the three machines produce 12 pieces per hour, this output being based, as stated, on the timing for the largest gear. Fig. 3 shows the line of machines from the delivery end. It will be seen that the conveyor is of a different type from that used on the single machine. It is worked by a hydraulic cylinder powered by the last machine in the line and reciprocates to produce the indexing steps required, the components being pushed along by pawls.

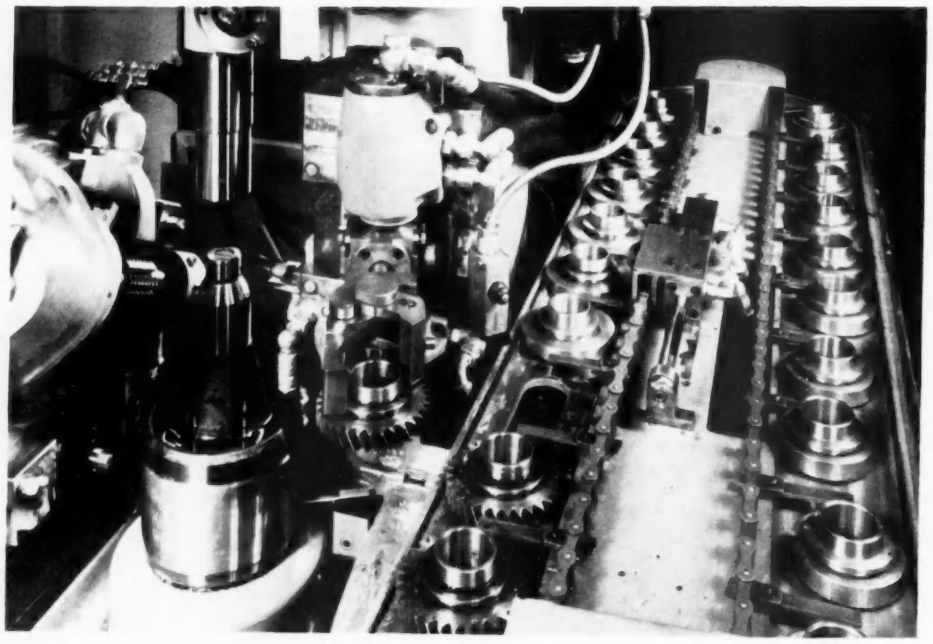


Fig. 2 The transfer arm, here moving a cut gear out, can be adapted very easily for different gears, as can the conveyor, which in this instance is of the simple push type.

Fully-automatic transfer lines are not confined to arrangements of one machine for each gear. The layout shown in Fig. 4 has six machines in line, but is only cutting three gears. A higher output is the deciding factor in this case, and there are two machines for each gear, the conveyor indexing each time through the distance necessary to present two components for identical operations on two adjacent machines. The gear cluster in this case comprises two helicals, one of 22 and one of 19 teeth, and one spur of 14 teeth on a forged shaft 6⅛ in. long. With a hob speed of 310 r.p.m., a vertical feed of 0·060 in. per revolution of work, and climb cutting, the output, based on the gear with 22 teeth, is 60 pieces per hour. Somewhat lower feed rates than are normally obtainable are used on this line of machines because the component is

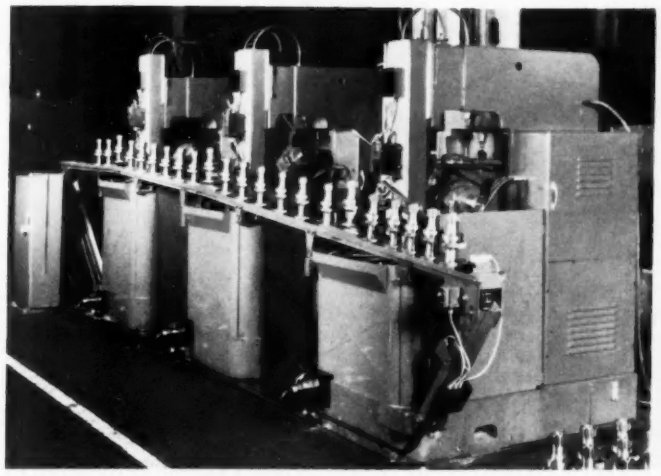


Fig. 3 For cluster gears several machines are used in line with a conveyor to carry the components between the machines.

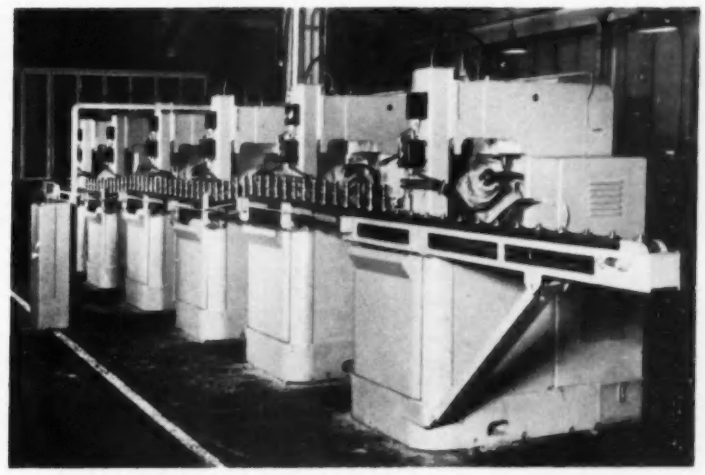


Fig. 4 A six-machine line is shown here, with the machines in three pairs, to deal with a three-gear cluster at an increased output rate.

required with very high quality finish in the gear roots.

The conveyor on this line is also different from the others. As will be seen from the illustration, which shows the line of machines from the feed end, with several blank component spaces vacant, the conveyor is of the chain type, with spigots for receiving and propelling the components. The three conveyors shown illustrate the versatility of the in-line layout which, by variations in the design of the conveyor, can cater for gears of any type, whether they will stand up on their own or not, and with or without holes suitable for spigots. The machine transfer arm, since it lifts the component vertically off the conveyor and lowers it back, and is accurately located at the end of its travel, is equally suitable for use with spigots or flat skid surfaces.

When machines are used in a line a main control station is supplied. This is a switch cabinet, which can be seen on the left of both Fig. 3 and Fig. 4. A rotary switch on this cabinet gives a choice of three settings "automatic running," "stop at end of cycle," and "individual running." The first of these is self-explanatory. The second can be used for stopping the machines when necessary as, for example, at the end of the normal working period. In this position the switch will cause all the machines to complete their cycle and the whole line will then shut down. To re-start the line it is only necessary to set the switch to the automatic position and press the start button. "Individual running" cuts out the overall control of the machines as a group, but does not affect the automatic cycle of an individual machine. Any or all the machines can then be run under completely independent control, making use of the normal push-buttons, for setting or adjustment purposes.

AUTOMATICALLY TUNED RADIO

Crystal Controlled Direction Finder

Those people who remember the days of sound broadcasting will recall the frustrating experience of tuning into an unfamiliar station. Perhaps a Continental station was broadcasting a concert of music rarely played in this country. In seeing the details of the programme the would-be listener would note that to receive the broadcast he would have to tune his set to a particular wavelength or frequency. This seemed simple enough. However, often in practice even when the pointer was at the desired wavelength, no amount of adjustment of the volume and tone controls could dispel the feeling that the sounds issuing from the loudspeaker not only bore no resemblance to the desired programme, but also bore no resemblance to any programme.

The station was, of course, broadcasting on the correct wavelength. The difficulty arises because domestic receivers rarely have an accurate frequency calibration. It is true that some sets are well calibrated, and it is also true that even with accurate calibration the congested condition of the broadcast bands makes almost any Continental station uncomfortable to listen to.

However, radio is used for other purposes besides entertainment. A particularly important application is in direction finding equipment for civil and military aircraft. The majority of automatic direction finders are arranged so that when the set is tuned to a particular station, a dial in front of the pilot or navigator indicates the true bearing of that station. Having a list of the exact positions of the main transmitting stations, the navigator can quickly obtain cross-bearings which pin-point his position. An important feature of the technique is the necessity of tuning to the wavelength of the desired station as quickly as possible. For, with high-speed aircraft, bearings must be obtained rapidly if they are to be of any use. Thus the need for an accurate tuning system is apparent, and the ideal arrangement would be one in which the pilot could set up the exact frequency required on some form of digital system and thus be no longer dependent on the accuracy of a simple pointer and scale. This object has been pursued with a considerable degree of success by Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex, in their new automatic direction finder type AD.712.

The equipment consists of three units: a directional aerial system, the main receiver, and the controller. The main feature of the controller is the digital frequency selector which provides an unambiguous indication of the operating frequency. The frequency settings are in steps of 0·5 kc/s and band switching is fully automatic. The operation is as follows: the pilot or navigator sets up on the controller the frequency of the station he requires. This action causes the selection, out of 39 quartz crystals situated in the main receiver, of those crystals necessary to synthesise the frequency set up on the controller. At the same time a motor drives the tuning elements in the receiver—permeable cores—to one end of their range and then starts to return them in the opposite direction. A comparison device compares the frequency of the tuned circuits with the frequency of the selected crystals and when the two become equal the motor is stopped and electronically locked on to the exact frequency required. The receiver is thus tuned to the frequency selected on the controller and the crystals act as a filter to remove unwanted signals. The need for tuning and a tuning meter is eliminated and the maximum error is ± 50 c/s (this is equivalent to about a 0·0005 in. movement of the pointer of a domestic receiver). The direction finding servomechanism then proceeds to evaluate the bearing of the signal coming in on the selected channel.

The direction finding system is conventional in principle although there are one or two unusual features. The receiver is a double superhetrodyne, with a crystal-controlled second local oscillator, and operates from a Bellini-Tosi aerial. The goniometer is embodied in the receiver and drives the bearing indicator directly. The loops of the aerial have been wound on ferrite rods and hermetically sealed in foamed resin. As a result the whole assembly projects less than an inch from the fuselage, requires a single 1½ in.hole, and contains no moving parts. Thus the loop requires no further attention once it is installed and icing troubles at high altitudes and problems arising from mechanical wear do not arise. The design of the circuitry and receiver couplings allow the use of a loop aerial feeder of up to 50 ft. and a sense aerial feeder of up to 60 ft., permitting the aerials to be sited at any convenient spot. The receiver, which contains a total of 26 valves, is built up of plug-in sub-units for ease of service and maintenance. The range of operation is 100 to 415 kc/s and 490 to 1,799·5 kc/s.

Control unit for automatic direction finder. The frequency is set up on a digital selector with a discrimination of 0·5 kc/s. The indicator allows the operating frequency to be checked at a glance.

SIMPLIFIED BOLTED JOINTS FOR HIGH FATIGUE STRENGTH

TIGHT CLAMPING, CLOSE PITCH, AND STRESS-RELIEVING GROOVES

By R. B. Heywood, PH.D., M.I.MECH.E.*

In this article, which is concerned with bolted joints for aircraft structural members, two extreme designs of joint are compared—one in which the proportions are carefully chosen so that the nominal stresses in sections are uniform, and the other of unorthodox design of the shortest possible length in which no taper is given to the individual members. The short joint, with closely-pitched bolts clamped tight and with a stress-relieving groove, is shown to be superior in fatigue.

Bolted joints having an exceptionally high fatigue strength and yet of simple form may be designed by applying the principles of (*a*) tight clamping by bolts, (*b*) high-density distribution of bolts, and (*c*) stress-relieving grooves. Results of tests on rectangular-sectioned joints designed on these principles indicate that life can be of the order of 70 times greater than that of typical aircraft joints, or that, for failure in a given number of cycles, approximately 3½ times the alternating stress can be sustained. The improvement in strength is such that the hazard of fatigue failures occurring in joints in aircraft (not at other parts) can be eliminated. In contrast, the careful tapering of individual members to obtain a more uniform loading at the hole sections may not by itself improve fatigue strength, but may give a strength no greater than that of typical aircraft joints.

The two types of bolted joints to be considered are representative of those used in structural aircraft applications, where load is transferred from an aluminium-alloy member to two outer straps by means of bolts in double shear. The alternating tensile loads applied in the fatigue tests are representative of those used at the Royal Aircraft Establishment for tests on joints on the tension side of an aircraft wing, when an estimate of the safe aircraft life is required.

Long Tapered Joint.—This joint comprised tapered inner and outer members in aluminium alloy D.T.D. 363A, and was secured by seven steel bolts in double shear on the line of pull (Figs. 1 and 7). The joint, designed by Mr. E. H. Mansfield for high static strength rather than fatigue strength, was given a taper in the members with the object of obtaining a more uniform distribution of stress at the various hole sections. The results of the fatigue tests are given in Appendix 1.

Short-Length Joint.—This joint was made of minimum length by placing the bolts at the smallest pitch consistent with ease of tightening the nuts by use of a box spanner. No taper was given to either the inner or outer members, and a generous diametral clearance was allowed between the bolts and bolt holes. The inner member was made of aluminium alloy D.T.D. 364B and the two outer members of mild steel. The general appearance of the joint and the method of attachment to the fatigue machine, are shown in Fig. 3, and its dimensions are given in Fig. 8. Photographs showing the appearance of the specimens after subjecting them to fatigue tests are reproduced in Figs. 4 and 5, and the results of fatigue tests, which are discussed in detail in Appendix 2, are plotted graphically in Figs. 9 and 10.

An alternative form of the short joint is shown in Fig. 8 (*c*) designated type B. The inner and outer members are reduced in thickness away from the joint to the dimensions at the base of the groove (or alternatively the ends of the members are enlarged) and the outer members are assumed to be made of aluminium alloy. Although no tests on this design have been undertaken, these alterations should not affect the fatigue strength.

COMPARISON OF JOINTS

The following comparisons of the joints are based on the gross cross-sectional areas of members, not on minimum areas. For the long tapered joint, specimen number 2, with tight clamping and giving the better fatigue results, is assumed to be representative of design. For the short joint it is assumed that the stress-relieving grooves of Fig. 8 (*b*) are incorporated. This type, designated type A, has the fatigue properties given by specimen number 11. For the short joint to type B shown in Fig. 8 (*c*) it is assumed that the strength is also given by specimen number 11. For type B the gross cross-sectional area of the inner member is taken as the full section away from the joint.

Weight.—The weight necessary to form the joint is taken as all weight additional to that for a continuous member. This weight can be expressed in terms of an equivalent volume of aluminium alloy. A non-dimensional parameter indicating weight can then be obtained by dividing this equivalent volume by the quantity $A^{1\cdot5}$, where A is the gross cross-sectional area of the inner member.

Weights obtained on this basis are compared in Table 1. The values indicate that the tapered joint is lighter, carrying approximately ½ to ⅓ the extra weight of the short joint. However, the disparity between the tapered joint and the short joint to type A would be much less if the latter were made with aluminium-alloy outer straps instead of steel ones.

Manufacture.—The long joint requires several extra operations in order to machine the tapers, with careful setting up in the milling machine. The fatigue failures started at holes, demonstrating that the quality of surface finish of holes, diametral clearance between the bolt and hole, and accuracy of pitch all affect the fatigue strength and should be accurately controlled.

In the short joint, failure occurred in the relieving groove, and therefore the quality of finish of grooves is important, but the standards required for machining the holes need not be high. A diametral clearance of $\frac{1}{64}$ in. was in fact used.

Length of Joint.—Length is important when considering the ease with which the joints may be fitted into aircraft. A comparison of lengths

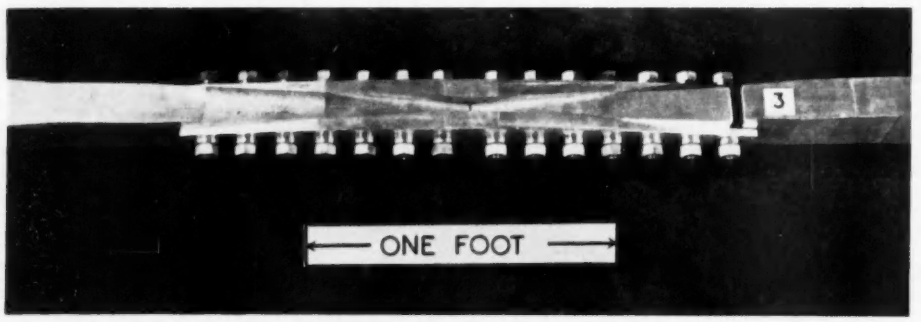


Fig. 1 First specimen of the long tapered joint, re-tested with new straps.

Fig. 2 The failure at the outermost bolt hole of the long tapered joint.

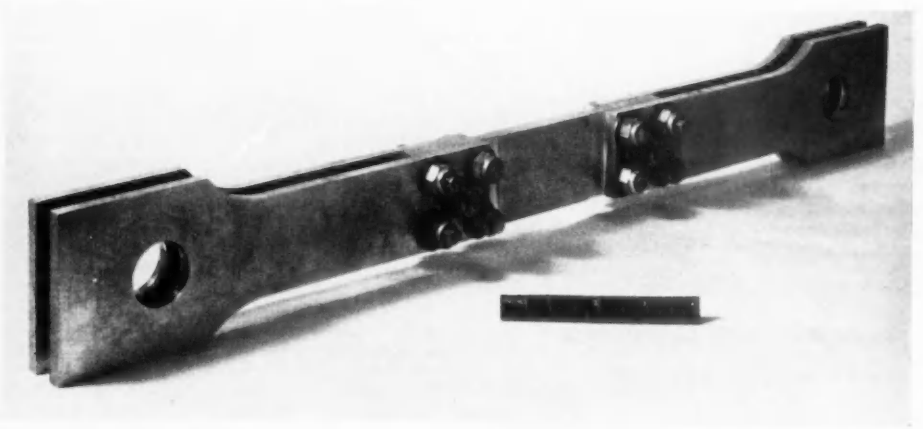
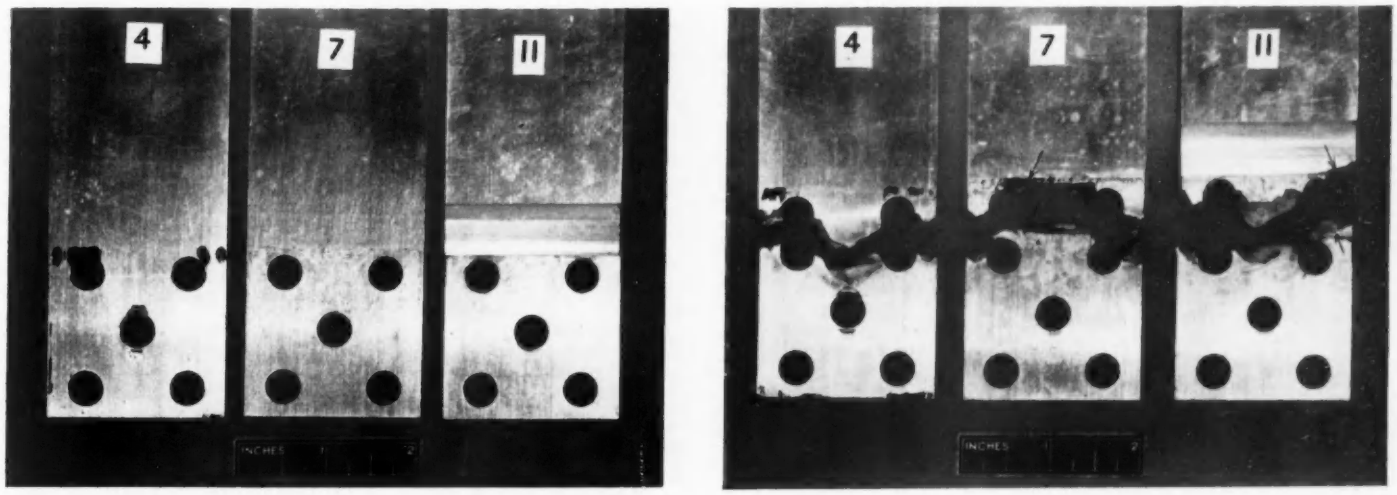


Fig. 3 The short-length joint specimen; at each end the specimen is attached by a connecting plate to the wedge grips of the Pulsator fatigue-testing machine.

* Royal Aircraft Establishment, Farnborough.



Specimen No. 4 .. .. .. 35 lb.-in. bolt torque
Specimen No. 7 .. .. .. 200 lb.-in. bolt torque
Specimen No. 11, with stress relieving grooves .. .. 300 lb.-in. bolt torque

Fig. 4 Typical failures of short joint specimens (the joints at both ends of the test specimen are shown).

is made in Table I by means of a non-dimensional parameter, obtained by dividing the length of joint by $\sqrt{A}$. The short joint naturally has a considerable advantage in this respect.

Static Strength.—As static tests were not made on all the joints it is assumed that the relative efficiencies in static tension are assessed by values of the ratio of nominal to gross cross-sectional areas. Values so derived are given in Table I.

Fatigue Strength.—To effect comparisons in fatigue it is necessary to standardise to given values two of the three variables mean stress, alternating stress, and endurance, and then to compare values obtained for the third variable. This procedure requires a knowledge of the relationships connecting the variables, and the method by which this has been done is given in Appendix 3.

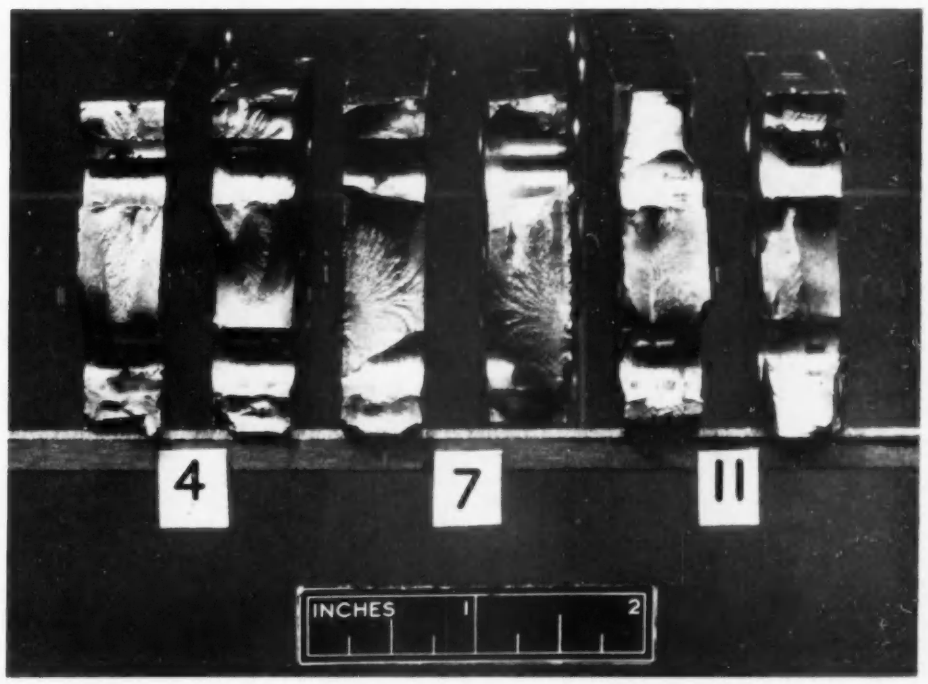
Comparisons are made for the following two conditions:—(*a*) a comparison of endurances on the assumption that all joints are subjected to the same arbitrary gross mean and alternating stresses of $8{\cdot}84 \pm 2{\cdot}94$ tons per sq. in.; (*b*) a comparison of alternating stresses on the assumption that joints are subjected to a gross mean stress of 8·84 tons per sq. in. and that failure occurs in 2×10^6 cycles.

The results, shown in Table I, illustrate the following points: (1) the fatigue properties of the long tapered joint are no better than those of typical aircraft wing joints; (2) the fatigue properties of the short joint are extraordinarily high, giving 100 times the life, or between four and eight times the fatigue strength of the long tapered joint.

TABLE I.—Comparison of Joints

—	Long tapered joint (Speciman No. 2)	Short-length joint Type A, Fig. 3 (*b*)	Short-length joint Type B, Fig. 3 (*c*)	Typical aircraft joint
Weight				
Expressed as equivalent length of inner member, in. $\left(\frac{\text{Extra volume}}{\text{gross cross-section area}}\right)$	7·4	11·4	12·5	
Non-dimensional parameter $\left(\frac{\text{extra volume}}{(\text{gross area})^{1\cdot5}}\right)$	3·8	11·6	15·9	
Length				
Length of joint, in.	11·0	2·0*	2·0*	
Non-dimensional parameter $\left(\frac{\text{length}}{\sqrt{\text{gross area}}}\right)$	5·6	2·0*	2·5*	
Static strength				
Percentage of tensile strength of full section $\left(\frac{\text{nominal area}}{\text{gross area}} \times 100\right)$	71	63	98	
Fatigue strength				
(*a*) Comparison of endurances at gross stresses of $8{\cdot}84 \pm 2{\cdot}94$ tons per sq. in.	24,000	2,200,000†	10,000,000	29,000
(*b*) Comparison of gross alternating stresses at gross mean stress of 8·84 tons per sq. in., and 2,000,000 cycles to failure ..	0·74	3·06†	5·78	0·84

* Length of relieving groove is not included. † Values may be pessimistic as specimen did not fail on test.



Specimen No. 4 .. Failure starting from bolt hole
Specimen No. 7 .. Failure starting from full section by fretting
Specimen No. 11 .. Failure starting from stress relieving groove

Fig. 5 Fractured surfaces of the specimens shown in Fig. 4.

ELIMINATING FRETTING

The fatigue results obtained for both types of joint demonstrate the beneficial use of clamping, as has been proposed by Fisher and Winkworth.[1] The proportion of load transferred by friction at the contacting faces of the inner and outer members reduces the remaining load applied through the bolt holes, and so reduces the stress at holes. There is also a reduction in the value of the stress concentration factor at the holes, due to the tendency for clamping to produce integral behaviour of inner and outer members, with a consequent reduction in distortion.

With effective clamping the point of initiation of failure is removed from the bolt hole to some point on the contacting face between the inner and outer members. As failure at a contacting face is invariably associated with fretting, the degree of improvement achieved by clamping is governed by the stress, pressure and relative movements which happen to be obtained at points of contact. Differences in these conditions explain why the long tapered joint gave an improvement in life of only 2·3 times by tight clamping, whereas the short joint gave an improvement of 27 times.

The short joint proposed in this paper was designed with the object of overcoming the

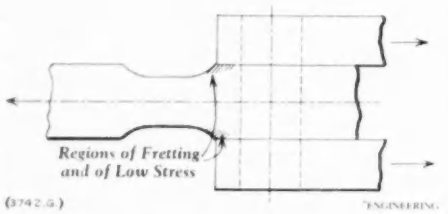


Fig. 6 (left) Coincidence of fretting and low stressed areas in clamped specimens with grooves.

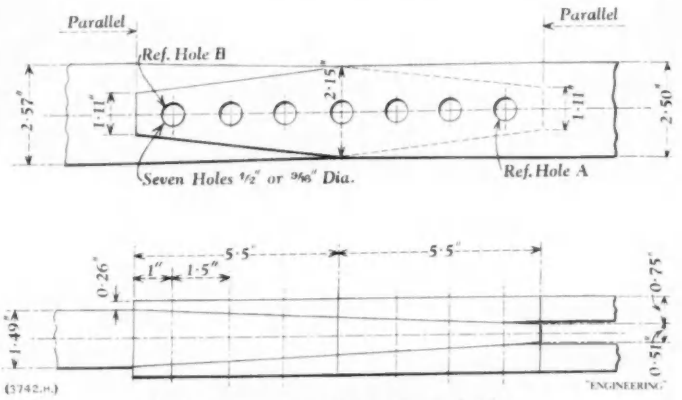


Fig. 7 Dimensions of long tapered joint.

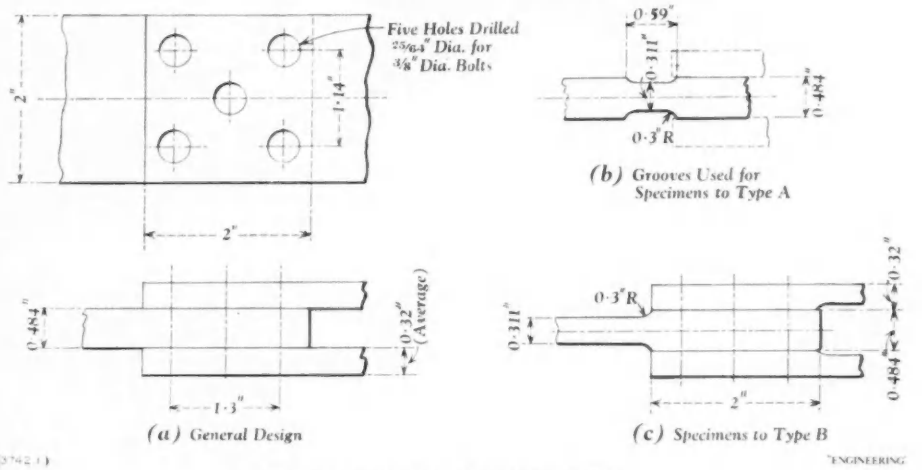


Fig. 8 Dimensions of short-length joint.

fretting type of failure at contacting surfaces by application of the following principles: (1) Fretting fatigue failures do not occur if all relative movement between contacting surfaces is eliminated. (2) Fretting fatigue failures do not occur if the stresses parallel to the surface are small.

Thus failure by fretting is caused by the combined effect of a high stress acting parallel to the surface and the relative movement at points of contact, whilst the presence of only one of these factors does not lead to failure.

One deduction from the first principle is that failure can be avoided by making the frictional forces at points on the mating surfaces sufficiently great to prevent relative movement. This was attempted with the joints under consideration by using a high contact pressure at all points, as obtained by distributing the bolts over the entire area of contact, using a very close pitch, and tightening with a high bolt torque. The close pitch enables the joint to be made of short length, since a sufficient number of bolts to satisfy static and fatigue requirements are contained within a small area. The close pitch also means that even without clamping, the differential strains between inner and outer members are small, and hence the need to taper individual members in order to obtain a more uniform shear loading of bolts becomes unnecessary.

The above reasoning is confirmed by the results of tests on the short joint. Specimen number 4 was given only a small bolt-tightening torque, and as would be expected, the relative movements produced potentially dangerous black fretting marks at many points on the contacting faces (Fig. 4). The failure actually started from a hole, due to the high load transmitted by the bolts (Fig. 5). In contrast, specimen number 7 was given a large tightening torque, and even although the endurance was much greater, fretting was virtually eliminated, except for faint markings near the inner line of contact of the joint (Fig. 4). At the failed end the large amount of fretting near this line of contact was probably due to the greater movements arising after formation of the crack.

The fatigue results of Table II show that the combination of a high bolt torque and close spacing of bolts has substantially increased the endurance—from 80,000 cycles with low bolt torque to 2,200,000 cycles with high torque, that is, by about 27 times. The effectiveness of the design is further demonstrated by specimen number 12, in which the outer members were moved outwards, so that attachment was by the end two bolts only. Remarkably, failure did not occur near these holes, but at the two inner unloaded holes, showing that the joint was stronger in fatigue than this unloaded hole section.

As fretting near the inner line of contact could not be avoided completely by tight clamping, an attempt was made to nullify its effect by applying the second principle for avoiding failure. A transverse groove was introduced near the commencement of the joint, as in the design to type A of Fig. 8 (*b*), so that the general tensile stresses induced by the load on the joint tended to by-pass the region in which fretting occurred (Fig. 6). The dangerous combination of high surface tensile stresses and fretting was thus avoided. The behaviour is demonstrated by specimen number 11 which did not fail after nearly 12 million cycles, as compared with the basic endurance of 80,000 cycles for the same joint without grooves and without clamping, or 2,200,000 cycles for the joint without grooves but with a high degree of clamping. Eventually

TABLE II—Effect of Bolt-Tightening Torque on Fatigue Strength of Short-Length Joints (without Relieving Grooves)

Specimen number	Bolt-tightening torque, lb. in.	Nominal fatigue stresses, tons per sq. in.	Cycles to failure: Individual results	Cycles to failure: Geometric mean	Position of failure
18	24	9·36 ± 3·11	69,000	81,000	At holes
15	24	9·33 ± 3·10	100,000		At holes
4	35	9·34 ± 3·10	78,000		Full section
9	130	9·23 ± 3·08	460,000	—	Full section
7	200	9·33 ± 3·10	1,160,000	1,330,000	Full section
19	200	9·31 ± 3·10	1,520,000		Full section
13	300	9·33 ± 3·10	380,000		Full section
20	300	9·34 ± 3·11	1,750,000		Full section
8	300	9·29 ± 3·10	3,000,000	2,170,000	Full section
16	300	9·52 ± 3·16	3,800,000		Full section
17	300	9·16 ± 3·06	6,400,000		At holes
10	400	9·27 ± 3·09	1,310 000	1,430,000	Full section
14	400	9·34 ± 3·10	1,560,000		Full section
12	300	9·26 ± 3·08	151,000*	—	At unloaded holes

* Outer straps moved outwards, clamping specimen by end two holes only.

TABLE III—Effect of Stress-Relieving Grooves on Life of Short-Length Joints
Bolt tightening torque = 300 lb. in.

Specimen number	Groove details, in.: Radius	Depth	Overlap	Nominal fatigue stresses, tons per sq. in.	Cycles to failure: Individual results	Cycles to failure: Geometric mean	Position of failure
13	∞	0	—	9·33 ± 3·10	380,000		Full section
20	∞	0	—	9·34 ± 3·11	1,750,000		Full section
8	∞	0	—	9·29 ± 3·10	3,000,000	2,170,000	Full section
16	∞	0	—	9·52 ± 3·16	3,800,000		Full section
17	∞	0	—	9·16 ± 3·06	6,400,000		At holes
11	0·3	0·086	+0·08	9·29 ± 3·09	11,900,000U		See Note 1
23	0·125	0·071	+0·13	9·01 ± 2·99	520,000		Groove fillet
28	0·125	0·070	+0·10	8·99 ± 2·99	420,000		Groove fillet
30	0·125	0·070	+0·10	9·00 ± 3·01	13,000,000U		See Note 2
33	0·125	0·070	0·00	9·00 ± 3·00	4,700,000		Groove fillet
29	0·125	0·070	−0·07	9·00 ± 2·99	4,000,000	3,270,000	Full section
24	0·125	0·070	−0·07	9·01 ± 2·99	9,300,000		Full section
27	0·125	0·070	−0·08	9·00 ± 2·99	8,000,000		Full section
5	0·025	0·050	+0·05	9·26 ± 3·09	84,000		Groove fillet

Note 1.—Specimen 11 subsequently broken by increasing loads to give nominal stresses of 14·0 ± 4·67 tons per sq. in. Fracture occurred in groove after 126,000 cycles.

Note 2.—Specimen 30 subsequently broken by increasing loads to give nominal stresses of 15·0 ± 4·96 tons per sq. in. Fracture occurred in groove after 90,000 cycles.

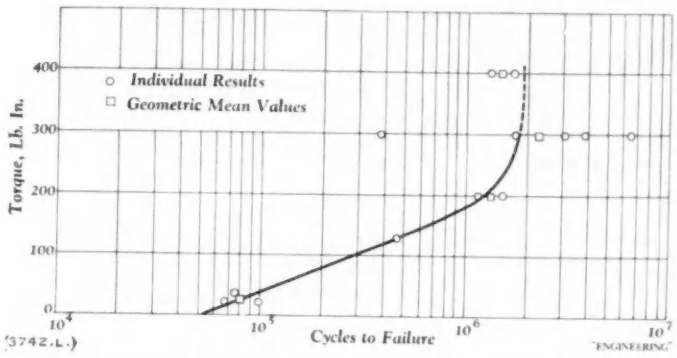


Fig. 9 (left) Effect of bolt-tightening torque on life of short-length joints. Nominal stresses 9·3 ± 3·1 tons per sq. in. approximately.

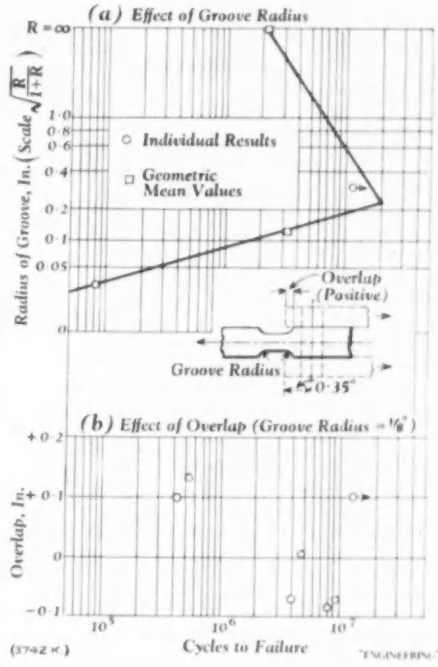


Fig. 10 (right) Effect of groove on life of short-length joints.

failure was obtained by increasing the mean and alternating loads by 50 per cent. when a fatigue crack developed in the radius of the relieving groove (Figs. 4 and 5).

Although only the one specimen (with a joint at each end) was tested with a relieving groove to the exact dimensions given in Fig. 8 (*b*), the evidence obtained from other grooved specimens confirms the effectiveness of grooves. The conclusion is reached that stress-relieving grooves of suitable proportions will prevent the fretting-fatigue type of failure in their immediate neighbourhood. As an additional precaution, an anti-fretting type of grease could also be used at the contacting surfaces.

Other known methods of improving the fatigue strength of joints are by the use of interference-fit bolts or bushes, and by the application of tensile overloads.[2] These methods are complementary to the clamping method in that they all improve the fatigue strength at holes. However, the interference-fit and overloading methods do not influence the propensity to failure by fretting at contacting surfaces, and this may impose an upper limit to the gain in strength that is possible. In contrast the proposed method of combining tight clamping by bolts at a close pitch with the use of stress-relieving grooves confines the fretting to a line of contact where it can do no harm. For this reason the latter method is potentially the best one to use for joints, and this is confirmed by the fact that the short joint investigated here has given appreciably better results than has been obtained with any other design of joint tested at the Royal Aircraft Establishment. This does not necessarily preclude the use of other methods, possibly in conjunction with clamping and relieving grooves, where the peculiar design conditions do not allow suitable proportions of joint to be used.

Acknowledgement.—The photographs and illustrations are Crown Copyright, and the author wishes to acknowledge the Controller, H.M. Stationery Office, for permission to reproduce them.

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APPENDIX 1.—FATIGUE TESTS ON LONG TAPERED JOINTS

The inner and outer members of the joint were machined from extruded D.T.D. 363A aluminium alloy, and for the purposes of test, the joint was duplicated and was attached to the machine through the inner members, which were strengthened at their extremities by means of Redux-bonded plates.

Two specimens were tested in axial loading in a 60 ton Schenck pulsator at loads of 18·7 ± 5·6 tons. The first specimen contained ½ in. outside diameter split bushes with tapered bolts, and failed after 118,000 cycles at the outer straps, at the end hole A in Fig. 7. The outer straps were then replaced with new ones and the test continued until failure occurred in the inner member, at the end hole B in Fig. 7, after 118,000 + 62,000 = 180,000 total cycles. The failure is shown in Fig. 2.

In the second specimen the split bushes were omitted, and the tapered bolts were replaced by parallel bolts of ⅜ in. shank diameter and ½ in. diameter B.S.F. threads. The bolts were screwed up as tightly as possible when using an 8 in. spanner. Failure occurred in fatigue in the outer straps at end hole A after 270,000 cycles.

The cross-sectional area of the two outer straps at the hole section A is equal to that of the inner member at the hole section B, and accordingly it is assumed for purposes of analysis that the fatigue strength of the inner and outer members is the same. The results are summarised in the Table below. The gross area is taken at the full section at the start of tapers.

Specimen number	Gross area, sq. in.	Stresses based on gross area, tons per sq. in.	Minimum area at first hole, sq. in.	Stresses based on minimum area, tons per sq. in.	Endurance cycles
1	3·82	4·89 ± 1·46	2·80	6·68 ± 2·00	118,000* 180,000*
2	3·82	4·89 ± 1·46	2·71	6·91 ± 2·07	270,000

* Failure of outer and inner members respectively.

APPENDIX 2.—FATIGUE TESTS ON SHORT-LENGTH JOINTS

The inner member of the joint was machined from D.T.D. 364B extruded bar and the outer members from mild steel plates, cadmium-plated after manufacture. The same outer plates were used for all tests, but in order to obtain correct representation, the surfaces were reground and replated after each test. All joints were assembled with Duralac jointing compound. The dimensions of the joint are shown in Fig. 8, the method of attachment to the fatigue machine in Fig. 3, and typical failures of test specimens in Figs. 4 and 5.

The specimens were tested either in a 60 ton Schenck Pulsator or in a 20 ton long-base Avery-Schenck Pulsator at loads approximately equivalent to 5·68 ± 1·89 tons per sq. in., on the gross area of inner member, or 9·3 ± 3·1 tons per sq. in. on the minimum area across two holes. The results for different degrees of bolt-tightening torque are shown in Table II and are plotted in Fig. 9. There is a progressive increase in life of specimen with increase in torque up to about 300 lb.-in.

Stress-Relieving Grooves.—In a second series of tests on short-length joints, stress-relieving grooves were incorporated in the manner shown in Fig. 8 (*b*). An indication of the effects of fillet radius in groove, and of overlap (defined as the distance by which the extremity of the outer straps overlaps the groove, see Fig. 10) on the life of specimens were assessed, the results being shown in Table III and plotted graphically in Fig. 10.

A detailed examination of the fractured surfaces from the point of view of determining the effect of groove-fillet radius on life confirms qualitatively the trend shown in Fig. 10. At some optimum radius greatest life is obtained: for a smaller radius a high stress concentration is present in the fillet, so causing failure in the fillet, and for a larger radius, the surface stresses adjacent to the groove would not be sufficiently reduced, and this would cause failure on the surface by fretting. The optimum proportions for groove radius and depth are best represented by those used for specimen number 11, as shown in Fig. 8 (*b*).

A similar detailed examination of the position of fracture showed that the magnitude of overlap had little influence on life within the range investigated. The low results for specimens 23 and 28 did not appear to be associated with the large overlap, but with the close proximity of the bolt holes to the groove, so producing a non-uniform distribution of stress along the groove

APPENDIX 3.—COMPARISON OF FATIGUE STRENGTHS OF JOINTS

Standardisation for mean stress is made by using an empirical relationship suggested by K. D. Raithby from an analysis of Meteor tail-plane fatigue results, giving

$$f_m \propto \frac{1}{N^{\cdot}} \quad . \quad . \quad . \quad (1)$$

Where f_m = nominal mean stress (f_M = gross mean stress) and N = cycles to failure.

Standardising for alternating stress is made by applying an empirical relationship derived from an analysis of the behaviour of typical aircraft wing joints,[3] namely

$$f_a = 0{\cdot}67\left(1 + \frac{1{,}000}{\sqrt{N} + B}\right). \quad . \quad (2)$$

Where f_a = nominal alternating stress (f_A = gross alternating stress) in tons per sq. in., and B = a constant determined from the static conditions, and assumed to have the value of 600.

For the long tapered joint, the best result with tight clamping is used for comparison. For the short-length joint, the result for specimen number 11 with relieving grooves is used (type A, Fig. 8), where no failure occurred in 12 million cycles. For purposes of analysis it is assumed that the specimen actually failed in 10 million cycles.

The basic data assumed for the various joints are as follows:—

Type of joint	$f_M \pm f_A$ tons per sq. in.	$fm \pm fa$ tons per sq. in.	N	Gross area / Net area
Tapered joint	4·89 ± 1·46	6·91 ± 2·07	270,000	1·417
Short joint, type A	5·68 ± 1·89	9·29 ± 3·09	10,000,000	1·636
Short joint, type B	8·84 ± 2·94	9·29 ± 3·09	10,000,000	1·053
Typical joint*	4·92 ± 0·82fa*	6 ± fa	N*	1·22

* As represented by the results given by relationship (2).

Comparison of Endurances for Given Mean and Alternating Stress.

The endurances are standardised to the mean and alternating stresses obtaining in the short joint to type B, that is to $f_M \pm f_A = 8{\cdot}84 \pm 2{\cdot}94$ tons per sq. in.

By correcting in the ratio of areas for the tapered joint, the nominal stresses for the required conditions are $f_m \pm f_a = 1{\cdot}417\ (8{\cdot}84 \pm 2{\cdot}94) = 12{\cdot}5 \pm 4{\cdot}16$ tons per sq. in.

Standardising for mean stress by relationship (1) gives the endurance

$$N = \frac{6{\cdot}91}{12{\cdot}5} \times 270{,}000 = 150{,}000 \text{ cycles.}$$

To correct for alternating stress, relationship (2) is expressed in the form

$$\frac{N_2 + 600}{N_1 + 600} = \left(\frac{f_{a1} - 0{\cdot}67}{f_{a2} - 0{\cdot}67}\right)^2.$$

Hence for the new conditions

$$N_2 = -600 + (150{,}000 + 600)\left(\frac{2{\cdot}07 - 0{\cdot}67}{4{\cdot}16 - 0{\cdot}67}\right)^2 = 23{,}600 \text{ cycles.}$$

The endurances for the short joint to type A and for the typical joint having a fatigue strength as indicated in the above Table are ascertained by standardising by the same procedure. For the short joint to type B, no standardisation is necessary.

The comparison of endurance for the joints is given in Table I.

Comparison of Alternating Stresses for Given Mean Stress and Cycles to Failure.

The fatigue strength (alternating stress) is ascertained for the various joints on the assumption that failure occurs in 2 million cycles at a gross mean stress of 8·84 tons per sq. in. Correction for mean stress and cycles is again made by applying relationships (1) and (2), and leads to alternating stresses for the required conditions as follows:—

Type of joint	Alternating stress (± tons per sq. in.)	
	Based on gross area	Based on minimum area
	f_A	f_a
Long tapered joint	0·74	1·05
Short joint, type A	3·06	5·01
Short joint, type B	5·78	6·08
Typical aircraft joint	0·84	1·02

CASCADED EXCITERS FOR COLLIERY MOTORS

Nine Field Windings Used to Provide Accurate Control

The direct-current winders which have recently been installed by the General Electric Company, Limited, Kingsway, London, W.C.2, at the Silverwood and Cadeby collieries in the North-Eastern Division of the National Coal Board, are operated on the Ward Leonard system, the speed of which is controlled by exciters. Though this method has been successfully employed on various drives in steel works, notably those of the temper mills at the Trostre and Velindre works of the Steel Company of Wales, it has not so far been used on winders. The following article describes the equipment at the Silverwood Colliery, but is equally applicable to that at Cadeby.

The winder, of which a view is given in Fig. 2, has been designed to raise 525 tons of coal per hour from a depth of 2,299 ft. It is driven through single-reduction double-helical gearing by a 3,700 h.p. direct-current motor which runs at a speed of 0/320 r.p.m. and is supplied with direct current at 0/650 volts from a Ward Leonard set. This set is driven by a 11 kV synchronous motor, which is started by the reactor method.

The winder is provided with two parallel drums 18 ft. in diameter, one of which is clutched and the other fixed on the drum shaft. The rope is laid across the drum during coiling on the first layer, the grooving being designed to eliminate the undesirable " rope flap " which is experienced with the normal series of parallel grooves hitherto employed for multi-layer coiling.

The mechanical brakes, which are illustrated in Fig. 1, are of the variable pressure type and consist essentially of two engines. One of these is double-acting and for normal operation applies both sets of brakes. The other is of the weight type which, in the event of changing winding levels, applies the brake on the loose drum so that the clutch can be withdrawn. The clutch engine and the weight-brake engine are interlocked so that it is impossible to withdraw the clutch until the loose drum brakes have been fully applied or to release the brakes until the clutch has been engaged.

The rate of application of the brakes during the high-speed period of the wind is controlled by a slow braking valve which is operated by cam gear and restricts the flow of oil from the engine. Rapid application of the brakes is possible during the acceleration or retardation periods.

SPEED CONTROL SYSTEM

The speed of the winder is controlled by an exciter system which combines the features of a " three-field " generator with those of the Ward Leonard arrangement. It is claimed to be simple to operate and maintain and to be extremely sensitive, so that high accuracy is obtained. Its essential feature is the employment of a closed loop system in which a controlling input signal, proportional to the required speed, is compared with a signal proportional to the speed actually obtained at the system output. Any discrepancy between these two quantities corrects the output quantity continuously to the desired degree of accuracy. Since in large direct-current motors the speed and voltage are closely related, the system when applied to winders depends basically upon voltage control. By compensating for the voltage drop in the loop circuit a high degree of control is achieved.

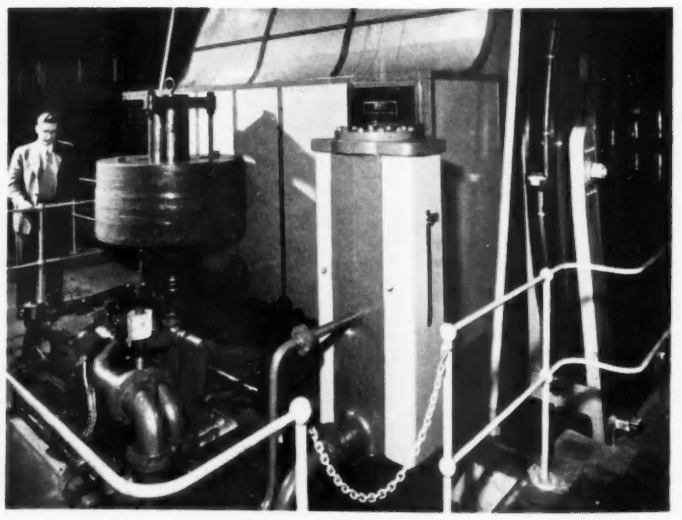


Fig. 1 Mechanical braking gear, which is able to exert a variable pressure, as installed on a colliery winder.

SOME GENERAL PRINCIPLES

The general principles of this control exciter system may be explained by reference to the basic circuit diagram given in Fig. 3. As will be seen the exciter has several field windings. The resultant effect of these determines the degree of excitation and consequently the output to the field of the main generator *a*, which supplies the winder motor *b*. Field *c* of the exciter is the control field and is energised by applying a " pattern " voltage. It is opposed by field *d*, which is excited by the main generator *a*. The series field *e*, which includes a stabilising section, and the stabilising shunt field *f* serve to prevent hunting, while the field *g*, which is shown connected in series with forward and reverse rectifiers across the shunt in the generator-motor loop, is the current limit field.

When the driver moves his lever from " stop " to " full on " maximum pattern voltage is applied to winding *c* of the control exciter *h*. This causes the control exciter to apply an initial forcing voltage to the field of the generator *a* so that its output voltage builds up quickly and the winder motor *b* is accelerated rapidly, that is, the system ensures that the speed of the winder responds promptly to the movement of the driver's lever. As the voltage of the generator *a* increases it applies increasing excitation to the field *d* of the control exciter. Since this field opposes field *c*, these two fields are almost in balance, and their resultant excitation, together with that of the stabilising fields, is of the value needed to produce the voltage in generator *a* necessary to run the winder motor at the speed determined by the position of the driver's lever. Any change in the output voltage of the generator *a*, or in the pattern voltage, at once disturbs this balance. The result is an increase or decrease in the output of the control exciter, and consequently of the generator, so that balanced conditions are rapidly and accurately restored.

Similarly, the movement of the driver's lever from full " on " to " off " reduces the excitation of field *c* to zero, leaving field *d* to provide high over-excitation in the reverse direction. This, in turn, forces down the excitation of the main generator *a* so that the winder motor *b* regenerates and is quickly brought to rest.

ACTION OF STABILISING FIELDS

The action of the stabilising fields is as follows: The series field *e* assists, and the shunt field *f* opposes, the control field *c*. When the generator field is changing rapidly, the current in the shunt field *f* rises more quickly than that in the series field *e* owing to the damping effect of the inductance of the generator field. Thus the immediate

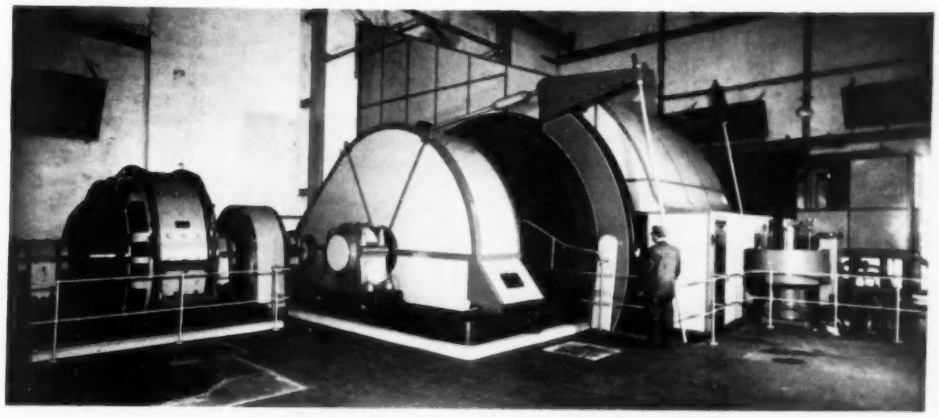


Fig. 2 The 3,700 h.p. geared direct-current winder installed by the General Electric Company, at the Silverwood Colliery of the National Coal Board.

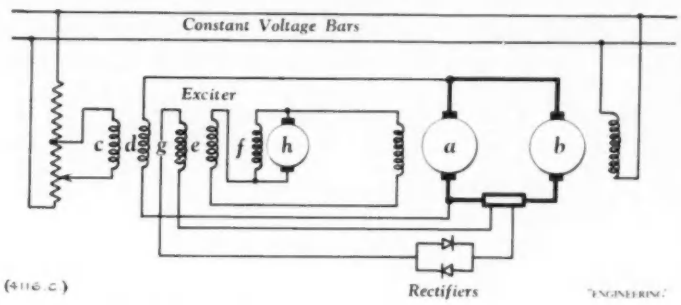
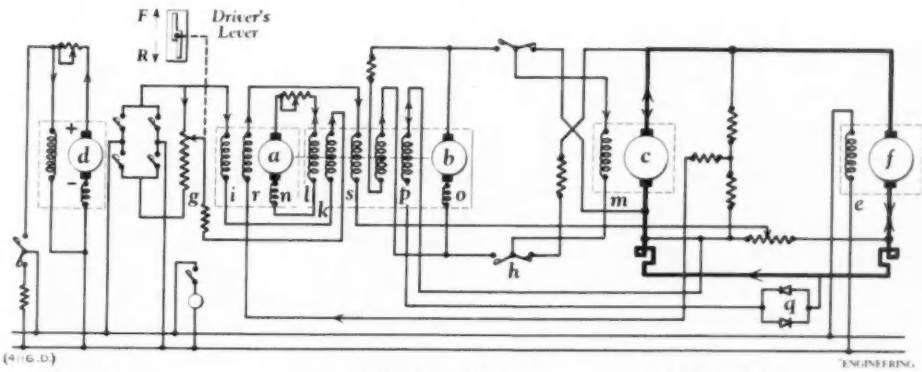


Fig. 3 Basic diagram of the control exciter system, showing current-limiting feature.

a Main generator
b Winder motor
c Control field
d Opposing field
e Series field
f Stabilising shunt field
g Current limit field
h Control exciter



a Pilot exciter
b Main control exciter
c Main generator
d Constant-voltage exciter
e Winder motor field
f Winder motor
g "Pattern" potentiometer
h "Suicide" contactors
i "Pattern" shunt field of pilot exciter *a*
k "Pattern" shunt field of main exciter *b*
l Main exciter field
m Main generator field
n, *o* Series fields
p Current-limiting field
q Rectifier
r, *s* Re-set fields of control exciter

Fig. 4 Diagram of control exciter system for 3,700 h.p. winder at Silverwood Colliery.

resultant of these two fields opposes the control field and the rate of response is damped. Overshoot is thus prevented should the pattern voltage suddenly change. On the other hand, under steady running conditions the resultant excitation produced by these two fields is such that the requisite output of the control exciter is maintained. With this arrangement the exciter is nearly self-exciting. This has the effect of increasing the accuracy of the system since any change in the input to the control field *c* will result in full output from the exciter.

The current-limit field *g* safeguards the machines by limiting the current during acceleration or retardation to a maximum safe value. When the current circulating between the winder motor and generator exceeds a pre-determined value the voltage drop across the shunt causes the circuit of the appropriate metal rectifier to become conducting. Thus any further increase in the current in the motor-generator loop causes an appreciable current to flow in the field winding *g*. Since this field opposes the control field *c*, the output of the exciter is reduced, thereby limiting the voltage of the generator *a* to a value which ensures that only a safe maximum current will flow through the winder motor *b*. Similarly, when the plant is stopping and the motor begins to regenerate, the reverse current flowing from the motor to the generator is limited to the pre-determined safe value.

PRACTICAL ARRANGEMENT

Owing to the size of the main motor and the degree of amplification required the winder at Silverwood Colliery is equipped with two control exciters which are connected in cascade. A diagram of the complete system is given in Fig. 4.

It will be seen from this diagram that a pilot exciter *a* feeds the field system of the main control exciter *b* (*h* in Fig. 3) and this in turn excites the main generator *c* (*a* in Fig. 3). A constant-voltage exciter *d* supplies the field *e* of the winder motor *f*, the brake solenoid and the operating coils of the various contactors and relays. With the winder motor at standstill and the driver's lever in the "off" position the pattern potentiometer *g* is de-energised and the customary "suicide" connection through the contactors *h* is made for the generator field. Movement of the driver's lever first actuates the appropriate contactors so that the main generator field is connected across the armature of the control exciter *b* and the potentiometer *g* to the constant-voltage line in the appropriate sense for the required direction of rotation. The selected voltage, as determined by the position of the driver's lever, is now applied to the pattern shunt fields *i* and *k* of the pilot exciter *a* and the main exciter *b*.

The pilot exciter then energises the field *l* of the main exciter. The three fields *i*, *k* and *l* being unopposed, a forcing voltage is built up across the main generator field *m* and a voltage appears at the generator terminals. The excitation of the exciters *a* and *b* is further assisted by the series fields *n* and *o*.

BRAKING EFFECTS

So long as the mechanical brake is applied the current flowing in the generator-motor loop circuit will be limited to a predetermined value (usually about twice full load) by the current-limiting field *p*, which is supplied through the rectifier *q*. On releasing the brake, however, the motor *f* will begin to accelerate and generate a back-electromotive force, but the combined effect of the control exciter fields *k*, *l* and *p* will be such that the excitation of the generator *c*, and consequently its voltage, will be automatically increased at the rate necessary to maintain the required current in the generator/motor loop circuit.

As the speed of the motor rises and the generator voltage increases, the re-set fields *r* and *s* of the control exciter set will be energised. The voltage applied to these fields is made proportional to the back-electromotive force of the motor by a resistance network so that it reflects very closely the speed of the motor. The fields *i* and *k* are now opposed by *r* and *s* and acceleration at constant torque continues until the motor reaches the desired speed. At this speed the fields *i* and *k* are very nearly balanced by *r* and *s*, a small difference being sufficient to maintain the requisite excitation and voltage of the generator *c*. Throughout the acceleration period the current-limit field *p* opposes the resultant field produced by the windings *k*, *s* and *l* so that the current flowing through the motor is limited to the desired value. Moreover, these three fields are so proportioned in relation to the characteristics of the pilot exciter *a* that the main exciter *b* gives its maximum output whenever the speed of the motor *f* differs from the required speed by more than 10 per cent. This slight "looseness" facilitates manoeuvring at low speeds by allowing a measure of torque control.

A similar sequence of events takes place when the winder is running at steady speed and the driver's lever is returned to "stop." Thus the winder speed is made to follow the position of the driver's lever very accurately, a temporary divergence being caused by the current-limit feature only.

★ ★ ★

RADAR FOR LYMPNE AIRPORT

Lympne Airport, saved by Skyways Limited from relegation by the Government to farming use, and now in good condition, is to be improved by the installation of Decca Type 424 airfield control radar, made by Decca Radar Limited, 1-3 Brixton-road, London, S.W.9. The set can be used for low surveillance out to about 20 miles range as well as for final precision-landing control in conditions of poor visibility.

The decision to instal radar sets has been necessitated by the success of the daily all-the-year road-coach and air service between London and Paris which the company inaugurated over a year ago. Operations will have to be highly intensified to provide for the 16 return services a day anticipated at peak periods this summer. Additionally, Skyways are planning to introduce a similar service between London, Lympne Airport and Lyons Airport and Nice. It is thought that in the second year of operation passengers on these services may number 200,000.

In order to ensure the utmost regularity and safety, the company selected the Decca equipment because it provides both "talk-down" facilities and local surveillance from a single unit.

1,000 TON COMPRESSION MACHINE FOR STRUCTURAL ELEMENTS

EQUIPMENT AT THE BUILDING RESEARCH STATION

By C. W. Newberry, B.SC.(ENG.), A.M.I.MECH.E.*

Until recently, the largest structural testing machine at the Building Research Station was one of 500 tons capacity having accommodation for test specimens up to 15 ft. high. This machine had been in constant use for some 25 years in the testing of walls and columns, but, with an increasing volume of structural research at the Station, it had become inadequate to keep pace with the projected programmes. The decision was therefore made to install another machine and at the same time to increase the maximum load capacity and the facilities for large specimens. The specification of the new machine called for a compressive load of up to 1,000 tons and the ability to accept, in a vertical position, test columns up to 20 ft. high and wall panels up to 12 ft. high by 7½ ft. wide. The machine had, moreover, to fit into an existing laboratory having an overhead crane 25 ft. above floor level.

The design was worked out by A. J. Amsler and Company, Schaffhausen, Switzerland, in collaboration with B.R.S. staff, and the machine was made by Amsler. The illustration shows the general appearance of the machine as installed at the Station.

LOWER PLATEN ARRANGEMENTS

The frame comprises a cast-steel base (located below floor level) in which are mounted four upright screw columns each 34 ft. long by 9½ in. in diameter which, in turn, carry the upper crosshead. The crosshead, which is a steel casting, has a built-in electric drive by which it can be adjusted to the required position on the screw columns to suit the size of test specimen. The base casting supports a hydraulic cylinder and ram to which pressure is applied to produce the test load, the maximum ram travel being 10 in. Thus far the machine is quite conventional. An interesting feature of the design, however, is in the arrangement of the lower table of the machine and the means of transmitting the test load from the ram to the specimen. A strut with fully-pivoted ends is interposed between the ram and the lower table so that horizontal forces which might be developed by asymmetric loading of the specimen cannot be transmitted to the hydraulic ram. Instead, they are transferred directly to the main columns of the machine through ball-bearing rollers which guide the lower table. This device assists in minimising the ram friction and so contributes to the accuracy of the machine.

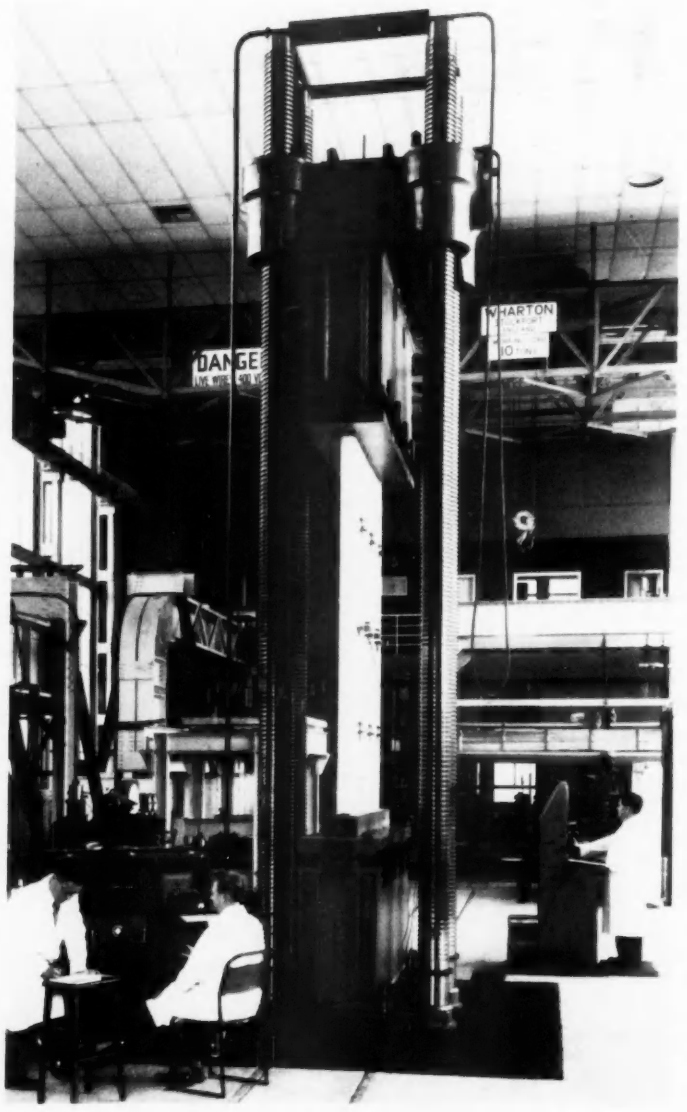
The lower table is arranged to be at floor level when the ram is just clear of its lowest position so that the lower platens, with test specimens already mounted, can be wheeled into the machine along rails laid in the floor of the laboratory. The upper platens bear against a special seating on the underside of the crosshead and are suspended by four long high-tensile steel bolts from a rocking plate which rests on top of the crosshead.

The normal platens for column testing are 20½ in. square and incorporate spherical seatings of conventional design. Screw-controlled wedges are fitted by which the angular freedom of the platen can be restricted as required. The upper platen is, in its essentials, similar to the lower.

Special platens are provided for testing columns under free-end conditions (buckling tests). The upper and lower platens are basically similar, each including an assembly of crossed roller segments so arranged that the centre of rolling in each direction is at the centre line of the face of the platen. The ends of the specimen are thus free to tilt in any direction with practically no restraint. Control is provided in each direction for limiting the angular freedom as desired and for the total locking of the platen to enable the specimens to be supported stable and erect while they are manoeuvred into and out of the machine.

LOADING WALL PANELS

For tests on wall panels the machine load is spread across the width of the panel by stiff transverse beams built up of heavy welded steel sections. Each beam carries a platen which can tilt about its longitudinal axis but can be restrained or locked by a series of screw-controlled wedges. The lower beam, as may be seen in the illustration, is fitted with wheels which run on the rails laid in the floor so that the beam, with the test specimen mounted, may be pushed easily into and out of the machine. The wheels straddle the lower table of the machine which rises between them to engage the lower side of the beam through a cylindrical roller segment having its centre of curvature across the upper surface of the beam platen. The beam is thus free to rock longitudinally, though four screw jacks are fitted to restrict the freedom as required. The upper beam, which is also fitted with a transverse roller segment on its upper face, is suspended by four long bolts from the rocking plate on top of the crosshead, the system being designed to absorb the strain energy released by the main screw columns at the instant of failure of a specimen.



The Building Research Station, Garston, have recently installed a 1,000 ton compression machine built by Amsler. Columns up to 20 ft. high and wall panels 12 ft. high by 7½ ft. wide. can be accommodated, and rockers ensure that the specimens are symmetrically loaded.

HYDRAULIC EQUIPMENT AND LOAD MEASUREMENT

Oil pressure to the loading ram of the machine is supplied by a six-cylinder high-pressure pump incorporated in a standard Amsler pendulum dynamometer, the pump delivery permitting a no-load ram speed of about ¾ in. per minute. The pendulum is adjustable to give load ranges of 1,000, 500, 200 or 100 tons, the load being indicated on a 16 in. diameter dial with indicating and maximum-reading pointers, and, if required, on an automatic drum recorder which draws a graph of load against compression for the specimen. A hydraulic load-maintainer, comprising a spring-loaded overflow valve on the oil supply and a device to reduce the delivery from the high-pressure pump, enables the load on the specimen to be held constant for as long as required.

Control of the machine is effected entirely from the pendulum dynamometer seen on the right of the illustration. The cabinet includes all the electrical contactors and fuses for the crosshead motor and the pump motor and has push-button controls on the writing desk.

Regulating valves for control of the ram speed and for pressure release are mounted on the panel immediately below the load-indicating dial and an emergency quick-release valve on the left-hand side of the cabinet. The equipment seen in the foreground of the illustration is a selector and indicator unit for wire-resistance and vibrating-wire strain gauges mounted on the wall panel under test and is not part of the machine control.

The machine has proved to be smooth in action, and after a few preliminary test loadings had been applied a calibration was carried out by the National Physical Laboratory. The differences between indicated and true reading were in all cases less than the tolerances claimed for the calibrating equipment, the performance of which was known to within ± 0·25 per cent. to 250 tons and to within ± 0·5 per cent. up to 1,000 tons.

Acknowledgment.—This article is published by permission of the Director of Building Research.

* Of the Building Research Station.

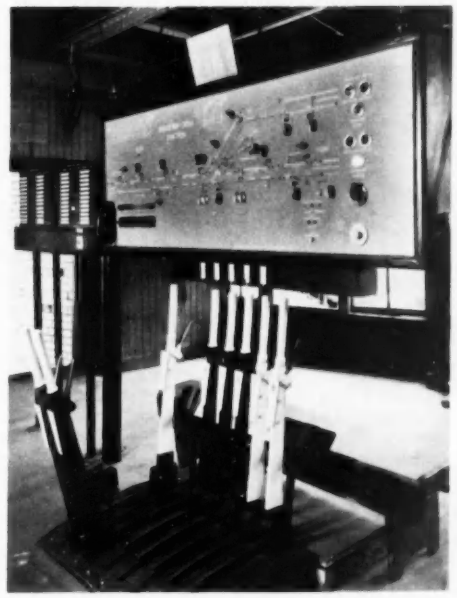
REPLACEMENT OF MECHANICAL SIGNALS

COLOUR LIGHTS FOR GLASGOW UNDERGROUND

In Glasgow there are some steam-worked underground railway routes, some of which belonged to the old North British and some to the old Caledonian Railway. Their signalling always had presented certain difficulties for, apart from the observation of signal indications being far from easy, maintenance of the equipment, which deteriorated rapidly in the fume-laden atmosphere, was both costly and hard to carry out. In spite of the great disadvantages attending the working, few accidents were recorded; but in recent years one or two have occurred, which have stressed the importance of introducing more up-to-date methods. This has now been done on the former Caledonian Central Underground line between Bridgeton Cross and Stobcross Junctions where the Tyer interlocking block, in service for some 60 years, has been replaced by continuous track circuiting and colour-light signals. The latter are nearly all of the multiple-aspect type which, in addition to giving much better visibility at all times, provides drivers with more definite advance information and enables them to run with considerably more confidence than does the mechanical signal, even in poor visibility.

Six signal boxes have been abolished, and at Bridgeton and Stobcross Junctions the existing ones re-equipped with electric-relay interlocking "panels" for controlling the signals, arranged over mechanical-type frames operating the points and point locks. By means of electric lever locks and circuit controllers the necessary inter-connection between panels and frames is established. Certain changes in the block-working arrangements with adjacent signal boxes also have been made in accordance with modern practice. The track circuiting is operated by alternating current with "double element" relays, and—to guard against any temporary loss of the "train shunt," possible at times under the very dirty conditions that can occur in the tunnels—special sequential circuiting has been resorted to whereby once a track circuit has been shunted its relay must remain de-energised unless the next track circuit in advance has become duly shunted in turn. Alternatively, in certain special cases where, for example, a setting-back shunting movement is involved and a train does not actually require to proceed into the next track signalling section, some other condition has to be correctly fulfilled. As a safeguard against a red signal aspect being overlooked in the bad atmosphere of the tunnels—something which might lead to serious consequences—each ordinary running signal has an electrically-operated detonator-placer maintaining fog signals on the line when the "stop" indication is exhibited. Certain signals have additional repeater signals, and at junctions the standard "junction indicator," the aspects of which are formed by rows of lunar-white lights set at an angle above the ordinary coloured aspects, is used. The equipment used in the tunnels, such as apparatus cases, telephone boxes, etc., has been specially designed to withstand the unfavourable conditions. Each main-line signal has a telephone, operating on a central battery circuit affording communication with adjacent signal boxes. During the time when Bridgeton and Stobcross Junction boxes are closed these telephones are connected to Strathclyde Junction, which itself is constantly in communication with the nearest box at the other extremity of the section which is open. Absolute block working is then in force, across the newly signalled section of route, between Strathclyde Junction and Partick Central, but normally none is in use and train describers function between Bridgeton and Stobcross Junctions.

Power is obtained from the local Corporation mains but there is a Diesel-alternator standby set at Glasgow Central station which starts automatically and assumes the signalling load if the outside supply fails. The greatly improved visibility of the signals and the adoption of multiple-aspects will be of assistance to drivers and should do much to eliminate delays.



Interior of Bridgeton Cross Junction signal box showing the "panel" for controlling signals, and the lever frame for working points and point locks. The train describers are on the left.

The contractors for the electrical signalling were the Siemens and General Electric Railway Signal Company, Limited, Wembley, Middlesex, and the installation was carried to completion under Mr. L. J. M. Knotts, signal engineer, Scottish Region of British Railways, whose staff put in the lever frames in the re-equipped signal boxes and did certain other work. The plans had been prepared and the work commenced under Mr. Knotts' predecessor, Mr. W. Bryson.

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WAVE ACTION IN EXHAUST PIPES

In a paper presented to the Institution of Mechanical Engineers, entitled "Wave Action in Diffusers for Exhaust Pipe Systems with Special Reference to the Scavenging of Two-Stroke engines," by F. J. Wallace and G. Boxer, the work described is an extension of the investigation into air flow in naturally-aspirated two-stroke engines described in an earlier paper. Trials were carried out on a motored opposed-piston engine, in which the variables were altered one by one, using exhaust pipes with diffuser cones of four different lengths. Three different theories for calculating the movement of gas in the exhaust pipe are discussed in respect to their particular accuracy; they are the method of characteristics; the small wave theory; and an analytical treatment which was a simplification of the first. The first, though extremely tedious, gave excellent agreement with observed results; agreement using the second was poor, and agreement using the third was superior to the small-wave theory, but somewhat inferior to the method of characteristics. However, since the work involved in the third method is considerably less than in the first, it was considered that this was a useful first approximation. It was also found that the air consumption using a diffuser cone showed a marked increase over that when a parallel-bore pipe was used, this being largely due to the elimination of the open-end reflection losses. An optimum value of diffuser length, having a length-diameter ratio of two, became apparent.

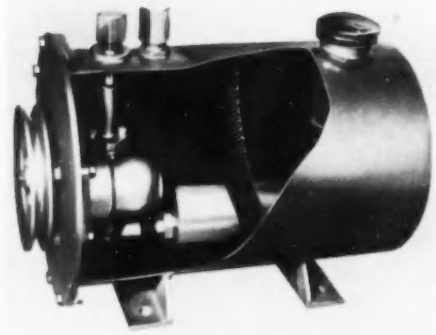
HYDRAULICS IN FIELD AND FACTORY

During the last five years the Plessey Company, Limited, Ilford, Essex, have developed a wide range of high-pressure precision hydraulic equipment for industrial and agricultural applications. The demand for these components, particularly hydraulic pumps for agricultural use, is now so great that the Plessey Group have recently allocated a new factory on the Rodbourne Trading Estate, Swindon, to the production of hydraulic pumps, rams and valves. The new factory, a single-storey three-bay building, will subsequently be followed by a nine-bay building and a second three-bay building into which other sections of the Plessey enterprise will be transferred.

At the Rodbourne factory, over 2,000 hydraulic components are currently turned out each week, of which about 1,000 are pumps for Ford agricultural tractors. In addition to special-purpose equipment, Plessey make a standard range of single and double-acting hydraulic rams in effective diameters from 1 in. to 3½ in., operating at a working pressure of 2,000 lb. per sq. in.; a wide range of control valves, including spool-type valves which can be ganged to form multiple-service controls; and gear-type pumps, with pressure-loaded bearings to minimise wear and maintain a high volumetric efficiency, in capacities from 0·27 gallons to 42 gallons per minute. One of the more recent Plessey products is the hydraulic power pack, which is fitted on the Massey-Harris combine harvester, shown in the illustration below. The power pack is designed to provide an independent source of hydraulic power wherever it is required. The pump drive can be taken from an engine or an electric motor, and the pack will operate as a complete self-contained unit.

The unit is constructed of heavy-gauge steel with welded ends and fittings. It incorporates a standard Plessey pump which is mounted on the end cover. The pump is immersed and carries a strainer on the inlet, which is located at the lowest possible level.

The power pack includes an anti-surge baffle, a quick-release filler cap and strainer, breather, an oil-level plug, drain plug, and mounting feet. The pump may be directly driven from the prime mover through a self-aligning coupling, or by belt or chain. The unit illustrated is for clockwise rotation but anti-clockwise rotation can be provided. The pump outlet on the unit illustrated is shown at the top of the tank with the return-to-tank connection next to it. An alternative arrangement can be made, allowing the circuit selector valve to be mounted on the tank, with the pump outlet connecting directly to it; thus, a complete unit would be formed requiring only the addition of connecting pipes for the rams or other services. This arrangement would allow the power pack to be located in a position convenient to the operator; but should this prove impracticable a separate selector valve could be connected to the tank which could then be placed in any position suitable to the installation.



The Plessey hydraulic power pack operates as a completely self-contained unit and can be supplied with directly-mounted control valves.

Book Reviews

HIGH LEVEL ARITHMETIC

Engineering Analysis: A Survey of Numerical Procedures. By STEPHEN H. CRANDALL. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (9.50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (71*s.* 6*d.*)

In recent years, the computational side of engineering has gradually acquired more and more importance. Evidence of this is easy to find. It is reflected in the recent establishment of university chairs in this country and, at a humbler level, has caused the enormously increased demand for computers. It has provided a stimulus in the development of high-speed automatic computing machinery and has greatly influenced the development of mathematics itself, as with the theory of matrices. In short, this is a subject which must be taken seriously. Furthermore, it must be taken seriously by engineers, since the importation of mathematicians merely to do computational work is scarcely satisfactory.

The sub-title of this book is worth noting; it is a " survey of numerical procedures." This is important because of the growing realisation that, generally speaking, the processes of arithmetic are much better suited to complicated engineering problems than are those of geometry. Graphical methods still have their place, but they are not being developed at anything like their former rate.

Professor Crandall is obviously well-equipped to write a book on engineering mathematics. He is both an engineer and a mathematician. His avowed intention is to show how a mathematical " model " can be selected to represent a physical state of affairs (or a physical happening) and then how the mathematical problem can be solved by a numerical procedure. The method of setting this down in print is effectively to divide the book into two portions; the first of which is devoted to discrete systems and the second to continua. Each half is then divided into three chapters which deal with equilibrium, eigenvalue and propagation problems.

Equilibrium problems are those concerned with steady states (of fluid flow, stresses and strains, oscillation and so on). Eigenvalue problems are those involving the determination of characteristic values, such as buckling loads or natural frequencies, each of which is associated with a " mode " of some sort. Propagation problems are those involving initial conditions and are found in the transient response of mechanical or electrical systems, the flow of heat and the propagation of disturbances. Each chapter starts with the discussion of a suitable selection of physical problems drawn from mechanics, heat transfer, fluid mechanics, structures and electricity.

The various types of problem which fall into the above categories give rise to algebraic, ordinary differential, and partial differential equations. The book thus amounts to a survey of the practical numerical methods that exist for solving these equations. As such, it covers iteration, relaxation, perturbation, variational and finite difference methods. It should be noted that both linear and non-linear equations are mentioned in all the chapters except the two on eigenvalue problems although, naturally enough, the emphasis is on linearity.

The first chapter has to do with the solution of sets of simultaneous algebraic equations. Iterative and relaxation techniques are discussed at length, each with variations on the theme. For some reason, the matrix notation is not introduced at this stage, but in the next chapter. Mathematically, there would, perhaps, be small gain from moving matrices forward; but surely it would simplify the explanation of them. Chapters two and three are on the eigenvalue and propagation problems of discrete systems respectively. They are excellent.

The second part of the book deals with continua and is thus concerned with elliptic, parabolic and hyperbolic partial differential equations. The methods discussed include those using continuous functions as approximations as well as various finite difference techniques, including relaxation. The treatments of the calculus of variations and the method of characteristics in chapters four and six are particularly well done and effective.

The collection of problems that are set for the reader is a main feature of this book. There are more than 400 of them, mostly with their answers given. Some are intended simply to help to familiarise the reader with the text material. But a large proportion of them illustrate alternative approaches or show how the theory may be extended. It is as if the author is desperately anxious to pack as much of his subject as possible into the book. In fact, it is this outlook that may repel some engineers since so much theory is presented in the text that some topics have received less than adequate treatment. This drawback is not as serious as it might be, however, in view of the large number of references to other books and to original papers.

The mathematical level of this book is about that of (good) honours engineering graduates, that is to say it requires a certain degree of mathematical maturity. It is difficult to imagine many practising engineers wading through it without assistance and the book will probably find a great deal of use in American universities, for courses leading to the master's degree in engineering. To the reviewer, the book serves as an eloquent reminder of the scope for improvement in British facilities for engineering education at the graduate level.

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MORE KNOTS

High-Speed Small Craft. By PETER DU CANE. Second edition. *Temple Press, Limited, Bowling Green-lane, London, E.C.1.* (40*s.*)

This new edition of *High-Speed Small Craft* is considerably more technical than the first, but the conversational style and the " nothing like messing about with boats " atmosphere is still to be found, so that its appeal is enhanced rather than limited. There are a number of new chapters : on the principles underlying the performance of planing craft in theory and practice; rudder design in plan form and section; reinforced plastics for boatbuilding; light alloys in high-speed craft; propelling machinery; and the use of models for prediction of behaviour in rough water.

All these chapters are worth-while additions containing up-to-date accounts of relevant material, accompanied by good bibliographies. The account of the action of planing surfaces draws heavily on published material from the David Taylor Model Basin and the Stevens Institute of Technology Experimental Towing Tank, and it is all the better for that. An attempt is made to show that the Froude law is applicable to planing phenomena " to a useful extent." However, the reasoning is not quite rigorous and the result does not agree with what two-dimensional theory there is. Admittedly, there is no three-dimensional theory worthy of the name. Apart from this, the author has done very well to present so much of the known state of the art in so little space and in readable form. The section on rudders is again very well done, but the author says that a good and sufficient rudder design alone will not ensure satisfactory turning performance. Nothing quantiative is given about the extra factors. The book contains a wealth of interesting information concerning such matters as the technology of reinforced plastic boats, the origins of dry rot in wood, and gas-turbine propulsion.

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Introduction to Stud Welding. By W. T. AMISON. *The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey.* (3*s.*)

The object of this 55-page pamphlet is to assist design and production engineers to make the utmost use of stud welding, where savings of time and materials are important. Stud welding is defined as an electric arc-welding process which, by inter-metallic fusion of a stud and a base metal, unites them as one under rigid time, heat and impact control conditions. The equipment required for stud welding, the methods and materials employed, and the testing of welded assemblies are described, and typical applications are given.

Leather Hydraulic Packings Manual. *Mechanical and Hydraulic Leathers Manufacturers' Association, 1 Booth-street, Manchester, 2.* (3*s.*)

Beginning with sections on the selection and preparation of leather for the manufacture of various types of hydraulic packings, this little 60-page manual then deals with cup leathers, hat or flange leathers, ram or U-packings, V-leathers, flat static seals and special seals—the last mentioned comprising all diaphragms and valve leathers falling outside the categories classified above. There are 26 line illustrations, and recommendations on installation, lubrication, storage and ordering are included.

Oxidation Resistant Silicon Aluminium Steels. By E. A. BRANDES. Special Report No. 2. August, 1956. *Fulmer Research Institute, Limited, Stoke Poges, Buckinghamshire.* (10*s.* 6*d.*)

Research on steels containing up to 4 per cent. of silicon and up to 3 per cent. aluminium have shown that steels containing from 2 to 3 per cent. silicon with 0·5 to 1 per cent. aluminium are comparable in resistance to oxidation, at temperatures up to 900 deg. C., with 18 per cent. chromium, 8 per cent. nickel austenitic steel. A detailed account of the investigation carried out to ascertain the properties and possible applications of these steels is contained in the above Special Report No. 2.

The Fatigue of Metals. Lectures Delivered at the Institution of Metallurgists' Refresher Course, 1955. *The Institution of Metallurgists, 4 Grosvenor-gardens, London, S.W.1.* (25*s.*)

The five lectures delivered at the ninth refresher course arranged by the Institution of Metallurgists dealt with various aspects of the subject of the " Fatigue of Metals." The authors of the lectures are Dr. J. Holden, Mr. G. Forrest, Dr. P. B. Walker, C.B.E., Dr. R. B. Waterhouse, and Mr. P. H. Frith. Sixteen double-page tables of useful data on fatigue are included at the end.

The Speedicut Manual of Screw Thread Tools. *Firth Brown Tools, Limited, Speedicut Works, Carlisle-street East, Sheffield, 4.* (25*s.*)

The aim of the compilers of this manual has been to provide an informative and practical guide and work of reference for users of screw-thread tools. While various methods of thread production are dealt with, the main emphasis is on screwing taps. Tap and screw-thread nomenclature and definitions are given, and many different types of taps in general use are described. Lists of tapping drill sizes, notes on lubrication and other data are included.

Tinplate Handbook. By W. E. HOARE. Third edition. *Tin Research Institute, Fraser-road, Perivale, Greenford, Middlesex.* (Gratis.)

The extent of the revision and of the additions made to this new and enlarged edition may be judged by the increase in the number of pages, from 31 in the last edition to 44 in the present one. The book deals with the manufacture, grades, qualities, packing, methods of ordering and testing, and applications of tin-plate. Statistics regarding the world production of tin-plate and a glossary of tin-plate terms, in English, French, German and Spanish, are also included.

The Use and Welding of Aluminium in Shipbuilding. Symposium organised by the Institute of Welding, the British Welding Research Association, the Institution of Naval Architects, the British Shipbuilding Research Association and the Aluminium Development Association. *The Institute of Welding, 29 Park-crescent, London, W.1.* (32*s.* 6*d.*)

The proceedings of this symposium, held on December 7 and 8, 1955, contain the 21 papers presented, together with a full account of the discussion and a number of written contributions. The symposium

covers most aspects of the welded fabrication and utilisation of light alloys in shipbuilding, also drawing upon the experience of important shipbuilding countries overseas. Three of the papers presented are by specialists from France, the Netherlands and Norway, while many participants from overseas contributed to the discussion. The subject is divided into four main divisions, dealing respectively with welding processes and techniques, materials and design, applications, and economic factors.

Plasticité. (Déformations Élastico-Plastiques.) By A.-A. ILIOUCHINE. Translated from the Russian by A. POPOFF and P. THOMÉ. *Éditions Eyrolles, 61 Boulevard Saint-Germain, Paris 5e, France.* (5,300 *francs.*)

The author deals with one of the three phases of the mechanics of plastic deformation and devotes his work to the theory of elasto-plastic deformation. He is concerned with three fundamental mechanical properties of solids beyond their elastic limit, namely, non-linear stress-strain relationships; consolidation during the course of deformation (cold-working); and the difference between loading and unloading curves.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Solders and Soldering Machines. FRY'S METAL FOUNDRIES LTD., Tandem Works, Merton Abbey, London, S.W.19. A new Flowsolder machine enables printed circuit boards to be soldered in a production line. The printed circuits pass in a straight continuous line through the crest of a solder "wave," and the underside of the board is thus "washed" with a continuous flow of clean solder at the correct temperature. Illustrated booklet. Other technical booklets deal with fluxes, fusible alloys, soft solders for use at elevated temperatures, solder paints, and similar matters.

Medium Speed Diesel Engines. MIRRLEES, BICKERTON AND DAY LTD., Hazel-grove, Stockport. "JL" range of Diesel engines, from three to eight cylinders in line, 132 to 1,200 b.h.p. at 900 r.p.m. Both normally aspirated and supercharged types. Illustrated booklet.

Commercial Lighting. A.E.I. LAMP AND LIGHTING CO. LTD., Crown House, Aldwych, London, W.C.2. Fittings for commercial lighting installations—shops, offices, churches and public buildings. Including pendent, ceiling, bracket and special types for tungsten lamps. Catalogue.

Storage Trays. PRECISION COMPONENTS (BARNET) LIMITED, 13 Byng-road, Barnet, Hertfordshire. "Kabi" midget assembly and storage trays for bench mounting. Phenolic mouldings interlocking together to form both straight and curved lines. Three sizes. Leaflet.

Measuring Instruments. ERIC H. BERNFIELD, LTD., 282 Kingsland-road, London, E.8. Continental measuring instruments and tools. Including calipers, height and depth gauges, micrometers, comparators and tachometers, and machine vices. Leaflets.

Combustion Control. JAMES GORDON AND CO. LTD., Dalston-gardens, Stanmore, Middlesex. Automatic combustion control equipment, including CO_2 recorders, pressure and flow controllers, relays and servomotors. Leaflet No. 110.

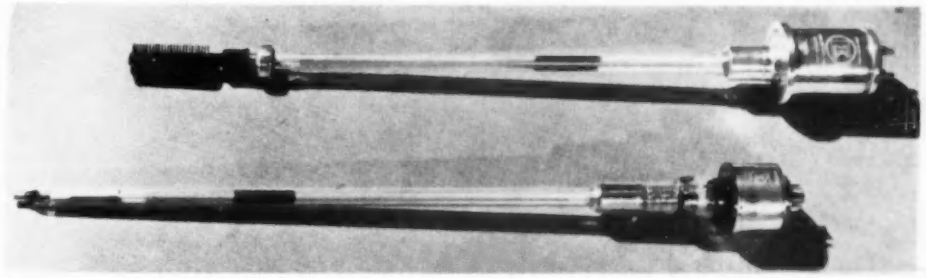
Tar Works. CHEMICAL ENGINEERING WILTONS LTD., Bird Hall-lane, Cheadle Heath, Stockport. Tar distillation and extraction plant as installed at Avenue carbonisation plant near Chesterfield. Illustrated descriptive booklet with flow diagrams.

Diesel Engines. MIRRLEES, BICKERTON AND DAY LTD., Hazel-grove, Stockport. "KV" range of Diesel engines, 12 or 16 cylinder, normally aspirated or supercharged V-type, up to 4,128 b.h.p. Illustrated brochure.

Coke Ovens and Steelworks Plant. SIMON-CARVES LTD., Cheadle Heath, Stockport. Illustrations and brief descriptions of coke-oven and other steelworks plant built by the firm at Jamshedpur, Hirapur and elsewhere, in India. Booklet.

Metal-Melting Furnaces. METALECTRIC FURNACES LTD., Cornwall-road, Smethwick, 40, Staffordshire. Metalectric-Calamari mains-frequency electric non-ferrous metal melting furnaces. Illustrated leaflets of ratings, dimensions and capacities.

Hydraulic Test Equipment. DOWTY GROUP LTD., Cheltenham. Complete test rigs and separate items for testing fuel pumps, gear pumps, injectors, burners and the like. Brochure.



Travelling-wave tubes of the type to be used in the radio link between Lisbon and Montijo. This device is superior to the klystron and disc-sealed triode, in multi-channel radio links, by virtue of its high gain and wide bandwidth.

MICROWAVES ACROSS THE TAGUS

RADIO PREFERRED TO SUBMARINE CABLE

The installation of a radio-telephone system to span the river Tagus from Lisbon on the northern bank to the industrial area of Montijo in the south is to be carried out by the Anglo-Portuguese Telephone Company. The distance covered is aboug 14 km. and the equipment will ultimately provide 240 circuits. A radio system was chosen in preference to a submarine cable since local conditions make cable laying a difficult operation. It was calculated that about 50 km. of cable would be required to provide the same service as the automatic radio system,

The radio equipment, which is being supplied and installed by Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex, consists of two Marconi HM.200 multi-channel terminal units and aerials. A detailed description of the equipment apears at the end of this article. Frequency modulation is used in the frequency band of 1,750 to 2,300 Mc/s. An advantage of operating at ultra high frequencies is the possibility of using high-gain aerial systems, since at these frequencies such systems have a reasonable size. The equipment for the Lisbon-Montijo link uses spun aluminium paraboloid aerials of 10 ft. diameter, which are claimed to have a gain of 30dB over a half-wave dipole.

TRAVELLING-WAVE TUBES

An outstanding feature of the radio equipment is the use of travelling-wave tubes for amplification at the ultra high frequencies. The tubes exploit the interaction of an electron beam and a travelling electromagnetic wave. As such waves travel at the speed of light they have to be slowed down if they are to interact with the electron beam in the right way. For the best results the two should be travelling at approximately the same speed, and to achieve this the slowing down is effected by passing the wave along a helix or similar "slow-wave" structure. In practice when a helix is used the signal to be amplified is fed into one end of the helix and it then travels as a wave along the wire. The axial component of the wave travels at approximately the speed of light multiplied by the ratio of helix pitch to helix circumference. An electron beam, which interacts with this component, is fired down the middle of the helix from an electron gun similar to those employed in the cathode-ray tubes of television receivers.

The action is analogous to that of a synchronous machine driven faster than synchronous speed—the helix corresponding to the stator. When the electrons move faster than the wave they give energy to the wave. When the electrons move slower than the wave, energy is extracted from the wave, and the tube acts as an attenuator. The second case corresponds to a synchronous machine running at less than synchronous speed. When the conditions are correct an exponential amplification of the wave occurs as it moves down the helix extracting energy from the electron beam. Consequently, the original signal appears at the end of the helix very much amplified. The great advantage of this technique is that the system is inherently non-resonant and can consequently amplify bands of frequencies that are enormously wide compared with those that may be dealt with by an amplifier with tuned circuits. Since the rate at which information may be communicated is proportional to the bandwidth of the communication system, the value of such tubes is clear. The illustration shows two of the tubes used in the Marconi equipment. The electron gun is housed in the structure at the right-hand end of each tube and the slow-wave structure extends down the length of the glass tube. This structure is a metallic spiral held accurately central by three quartz rods. It will be seen that the rods are coated with Aquadag for a portion of their length. This coating prevents self-oscillation in the tubes by attenuating backward-travelling waves. The main sources of noise in the tubes are fluctuations in the density and velocity of the electrons. The correlation that exists between the two processes allows suppression of some of the noise by careful attention to the geometry of the acceleration and focussing electrodes. Similar considerations enable some reduction in partition noise.

The electron beam is maintained in focus by an electromagnet extending the length of the tube but it is hoped that this may be replaced by a permanent magnet. The waves are fed on and off the helix by waveguides but throughout the remainder of the equipment coaxial-cable techniques have been preferred owing to their more compact construction and freedom from "transparencies."

The contract for the supply and engineering of the complete radio link was awarded to the Automatic Telephone and Electric Company, Limited, Strowager House, Arundel-street, London, W.C.2. It will be recalled that in April, 1956, A. T. and E. and Marconi's concluded an agreement for mutual co-operation in the telecommunications field.

Circuit Description

At the terminal the traffic signal from the channelling equipment is amplified in a conventional wide-band amplifier and converted to a frequency-modulated signal, at an IF of 70 Mc/s, in a three-valve modulator circuit. This IF signal is taken to a crystal mixer stage where it is mixed with a carrier frequency in the 2,000 Mc/s band. The carrier frequency is obtained via multipliers from a crystal-controlled oscillator. The modulated U.H.F. signal is taken from the mixer stage through a band-pass filter and is applied to an intermediate travelling-wave tube. The intermediate tube drives a high-power tube which is used as a power amplifier to deliver 10 to 15 watts output to the aerial feeder.

The incoming signal from the receiving aerial is applied to a low-noise travelling-wave tube having a noise factor of better than 10dB. The amplified output from this tube is mixed with the output of a crystal-controlled local oscillator to give an IF of 70 Mc/s. After amplification the IF signal is demodulated to the base-band frequency and the traffic signal is applied to an output line amplifier.

High-grade selenium rectifiers are used to obtain the D.C. supplies required by the terminal equipment; neon tubes and corona discharge tubes are used to stabilise some of the supplies to the travelling-wave tubes.

Marketing

DRIVING HARD FOR EXPORTS

The splendid export performance of Road Machines (Drayton), Limited, in recent years shows what can be done even by a small company if the top management are determined to force the pace. The firm are at present engaged in developing export sales in North America of a monorail conveyor system invented in this country and used with considerable success for the handling of concrete on unprepared rough construction sites and for multi-storey buildings. It can haul 1½ tons of mixed concrete up a gradient of 1 in 12 and half that weight up a gradient of 1 in 8.

The equipment is being manufactured under licence in the United States by the Chain Belt Company of Milwaukee and a Canadian company, the Drayton Construction Equipment Company, formed three years ago and operating in association with United Steel of Canada. Road Machines (Drayton) have subsidiaries in South Africa, France, Germany, and an associate company in Australia. A new company has just been formed to handle export business in the Soviet bloc countries—United Construction Company, Limited—and considerable demand is expected for both the monorail and the company's weighbatching and dumper equipment. A substantial order has been placed by Polimex, the Polish Government purchasing agency.

The head of Road Machines, Mr. W. M. Robb, has recently set off on a tour of North America. He considers the Canadian potential "unlimited" but warns that salesmanship is essential: "Contracts are not waiting to be picked up. On the contrary competition is fierce, but we have as a proud record the fact that since we started in 1951 we have exported the monorail system to no fewer than 26 countries."

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Manufacturing Overseas

Further evidence of the growing determination of British engineering companies to set up manufacturing facilities overseas was provided recently by the Pyrene Company, Limited, and J. W. Lawrence, Limited. Pyrene have purchased a company in Canada and launched a new manufacturing company in Australia. The purchase of C-O-Two Fire Equipment of Canada Limited for 310,000 United States dols. will considerably strengthen Pyrene's hold on that market, where their subsidiary The Pyrene Manufacturing Company of Canada, Limited, have been operating since 1954. The Australian company is to be formed as a joint enterprise with Pyrene's agents, Harrisons Ramsay Pty. Limited. New capital was raised for these ventures and the balance will be used to purchase "trade marks, patents and working drawings, and manufacturing and sales rights in various parts of the world."

J. W. Lawrence, who specialise in the manufacture of heat exchange equipment for the vehicle and aircraft industries, have concluded that the demand for automotive components is spreading very widely throughout the world and that the correct policy for the component manufacturers is to set up overseas manufacturing "in order to fulfil the local demand for spares or initial equipment and thereby avoid currency difficulties, long supply lines, customs duties, etc. . . ." They are therefore offering to enter into partnership with local interests in various markets to set up new radiator enterprises, providing the complete manufacturing plant and technical know-how in exchange for shareholdings.

The growth of overseas manufacturing is now gathering momentum and is likely to constitute the principal British participation in Commonwealth development during the next decade. The incentives are great, for not only is it one method of overcoming the trade barriers that have sprung up since the war, but also a means of investing in countries where the incidence of tax is less and industrial growth more rewarding.

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Markets Favourable

Britain's export prospects have improved since last October, owing to a strengthening of the internal economies of several countries. "Whatever the short-term implications of Suez for Britain's domestic economy, world demand for goods continues undiminished." These conclusions were reached by the economic and marketing research unit of the General Electric Company and are illustrated in the current issue of the G.E.C. Export Guide (see Marketing, of November 9).

The guide shows continuing good prospects for British exports to Canada, the Rhodesias, India, Switzerland, United States and Western Germany. Prospects are particularly good in Ceylon, the Gold Coast, Kenya, New Zealand, Nigeria, Sweden and South Africa. The outlook has improved in Argentina, Australia, Belgium, Norway and Spain. There has been deterioration in ten markets, the most important of which are Pakistan, Denmark, France and the Soviets, but prospects are really bad only in Egypt.

G.E.C. take the view that the formation of a common market in Europe will provide "an immense opportunity for enriching United Kingdom world trade" and advise British manufacturers to prepare for the development of exports in that direction and to reinforce their representation in this fast-expanding region "which in January to October, 1956, took £196 million of British engineering goods." But competition will be fierce, and only keen selling will bring rewards. Remarking that United States industry is not afraid of real competition from Europe, G.E.C. conclude that "with a Common Market in Europe, the European manufacturers will be better, if not much better, able to face transatlantic competition, not only in Western Europe but all over the world."

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Soaring Aircraft Sales

The exports of the British aircraft industry exceeded £100 million in 1956, the highest ever and 58 per cent. greater than in 1955. The United States was the best customer by far, taking £17·2 million of the £71·8 million worth of the aeroplanes and parts (excluding engines, electrical parts and appliances) exported. The sales of aero engines abroad totalled nearly £28 million, electrical appliances £2·7 million, instruments £1·4 million and tyres £0·7 million. Apart from the United States, the best markets were Australia, Sweden, France, Belgium, the Netherlands and Canada.

The announcement of the Society of British Aircraft Constructors containing these figures states that the industry "is determined to consolidate and expand established and recently won overseas markets." More than half the gas-turbine airliners on order (981) in the free world are British; representing many millions of pounds in business over the next 10 years. Guided missiles are to be added to the list of products available for export. Research facilities have been greatly improved in recent years and the Society quote a comment by Mr. E. T. Jones, the head of Scientific Research (Air) at the Ministry of Supply, "The industry is now equal to any task demanded of it."

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Guaranteed Credit

The commercial business transacted by the Export Credit Guarantee Department is increasing. At the end of the fourth quarter of 1956 the number of short-term policies current was 4,112 compared with 4,026 at the beginning of the quarter and 3,904 at the end of the corresponding quarter last year. The value of these policies at the end of the third quarter of 1956 was £546·6 million, about £57 million more than a year previously. There was an even greater increase in the value of new medium-term business transacted during the quarter, which suggests that the department are playing their part in meeting British industry's requirements for cover on the type of credit asked for in a number of markets—allegedly met without difficulty by German exporters.

The prospects for British exports, discussed elsewhere on this page, justify a substantial expansion of the facilities offered by E.C.G.D. and it is hoped that the rising trend in new policies will be continued. This is of particular importance to companies new to export business, or to those operating in markets of which they have had no previous experience. The fact that the total gross value of short-term and medium-term insured business declared as shipped during the quarter amounted to only £103·5 millions, suggests that the proportion covered by the department's guarantee is still a very small one.

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REPRESENTATION AT CONTINENTAL FAIRS

Following their successful participation in last year's Vienna Trade Fair, the Birmingham Exchange and Engineering Centre, Stephenson-place, has decided to participate in three trade fairs in 1957. These are the Leipzig Technical Trade Fair, March 3 to 14, the German Industries Fair, Hanover, April 28 to May 7, and the International Autumn Trade Fair, Vienna, September 8 to 15.

At Leipzig the Engineering Centre has been invited by the Fair authorities to set up an office in the Messedienst, the Fair headquarters. The Centre will provide visitors to the Fair with up-to-date information on the sources of supply of British engineering products and will generally act as an information bureau on the British engineering industry. In Hanover the Centre will co-operate with the Board of Trade in the British Government Enquiry Office. They will handle engineering inquiries received and will distribute literature and other information. At Vienna the Centre will work on the same lines as last year, handling, by arrangement with the Board of Trade, the engineering inquiries received at the British Pavilion. Their stand will distribute literature and display photographs and exhibit certain products.

The Committee of the Centre are anxious that all British exhibitors at these three overseas exhibitions should take the maximum possible advantage of the Centre's services and, whether members or not, are asked to supply literature on their products, in German if possible, to the Centre in advance. Mr. A. J. Cox, the Centre's Manager, will be in personal charge of the Centre's stand in each case.

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BUILDING A TANKER

For all those, young and old, who are or may be interested in shipbuilding, Vickers Limited have produced a film, taken by their own unit in Eastman colour, which gives a brief but interesting picture of the construction of the 47,000 ton tanker "Spyros Niarchos."

The shots include various stages of construction, the launching and fitting out, and a brief view of the tanker on trials. The film is available in both 35 and 16 mm. sound versions, and may be borrowed from the company at Vickers House, Broadway, London, S.W.1. It runs for about 15 minutes.

ATOMIC REVIEW

In a Nutshell

Owing to our shortage of orthodox fuels, atomic development in this country has been mainly concerned with large base-load stations. The Americans, on the other hand, have as yet no fuel problem, and because they have considerable stocks of enriched uranium have been able to concentrate on smaller plants. (Use of natural uranium is limited to reactor cores in excess of a certain size; thus enriched fuels are necessary for stations generating less than about 40 MW.) These compact low-power package reactors, though expensive to run, offer the best immediate prospect for export, particularly to the under-developed countries, where the cost of power from conventional plants is also high. Thus Britain, which has a special interest in the export market, has little experience of the type of reactor which is, initially at least, most likely to be required. This problem has been partly solved by an agreement outlined below, whereby a British company makes small reactors developed in the United States. An agreement of this kind has a significant advantage, for although the United States is best equipped to develop such reactors for the reasons given above, it may be more economical to manufacture them elsewhere. The American economy is geared more than ours to mass production; thus where an item is required in comparatively limited quantities (as in the case of a reactor) it may well be cheaper to make it over here.

British Firm to Build Package Reactor

Small nuclear power stations similar to an American prototype now nearing completion are to be marketed outside North America by a British company, Humphreys and Glasgow, Limited, who have recently concluded an agreement to this effect with Alco Products Incorporated of the United States. Another British company concerned in the agreement is Daniel Adamson and Company, Limited, who will make certain items of plant. Initially about two-thirds of the equipment will be obtained in this country, though later Britain would take over construction of the entire plant.

The reactors to be made will be similar to the 2 MW APPR-1 (Army Package Power Reactor No. 1) being built by Alco and now nearing completion at Fort Belvoir, Virginia, U.S.A. (see ENGINEERING, July 6, page 30, and December 7, page 734, 1956). Like the reactor fitted in the submarine Nautilus, which has recently completed 50,000 miles successfully in two years on one fuel charge, APPR is of pressurised-water design (cooled and moderated by light water under pressure), and is compact in size, as can be seen in Fig. 1, occupying an area roughly equal to that of a tennis court. It should be emphasised that no unusual construction materials are used, only mild and stainless steel, and that the design is inherently safe. The general layout of the reactor plant is shown in Fig. 2.

Humphreys and Glasgow are prepared to present definite proposals for steam generating plants (for heating purposes) or generating stations with electrical outputs ranging from 10 to 20 MW. (Alco pressurised-water nuclear power plants are at present available in three sizes with net electrical outputs of 2, 5 and 10 MW, though an extension up to 25 MW is in hand). Such stations would be sufficient to supply localities of from 20,000 to 40,000 people. The company are ready to quote firm prices and to specify operating costs. Thus the capital cost of a 10 MW power station including fuel hire charges would be about £2 million (£200 per installed kW) and the price of electric power before distribution would be between 1½*d.* and 2*d.* per kWh. Although this figure is high compared with 0·6*d.* or 0·7*d.* per kWh for Britain's projected base-load nuclear power stations, it should be borne in mind that for isolated sites and small powers, particularly in under-developed countries, the cost of transporting bulky conventional fuels, would make much higher power costs competitive. The charge of enriched uranium would weigh between ¼ a ton and 3½ tons, depending on the degree of enrichment (possibly ranging from 4 to 30 per cent.) and would last from 18 months to two years. At present it appears that enriched fuel will be supplied from American sources. An outline specification of the Alco 10 MW plant is given below.

Fig. 1 Reactor in a nutshell. The 14 ton reactor vessel is lowered into the domed vapour container of APPR (Army Package Power Reactor), now nearing completion in the United States. Similar small power reactors are to be built in this country for export by Humphreys and Glasgow Ltd.

General

Thermal power generated	46 MW
Electrical power generated	10·6 MW
Required for auxiliaries	600 kW
Net electric power available	10 MW
Thermal efficiency	22 per cent.
Uranium enrichment	4 to 30 per cent.
Core life before refuel at full power	18 months
Core life at 80 per cent. load factor	30 months
Control rods (number)	7 to 9
Average fast flux (approx.)	5×10^{14} neutrons per sq. cm. per sec.
Average thermal flux (approx.)	10^{14} neutrons per sq. cm. per sec.

Primary Loop

The primary loop comprises the reactor pressure vessel, steam-generator primary coolant, circulating pump and pressuriser. All surfaces in contact with primary coolant and the fuel element cans are of stainless steel. Fixed rate of bleed and equivalent make-up through demineralisers maintain the purity of coolant. Control-rods are driven by geared motor through rack and pinion, and magnetic clutch.

Moderator and coolant	light (natural) water
Water system pressure	1,500 lb. per sq. in. gauge
Circulation rate varies with enrichment. Typical rate (gal. per minute)	9,000
Coolant temperature at reactor inlet (typical)	252 deg. C. (485 deg. F.)
Coolant temperature at reactor outlet (typical)	270 deg. C. (518 deg. F.)
Reactor pressure vessel dia. (approx.)	4 ft. 6 in.
Reactor pressure vessel height	16 ft.

Primary Structures

(*a*) Vapour container, which also acts as biological shield. This is approximately 70 ft. in diameter and 70 ft. high and has a domed top. It is constructed of steel and fabricated by welding. It houses the complete high-pressure primary system and is so designed that it will contain the products of any nuclear incident which has been postulated.

(*b*) Primary shield of iron-water and concrete type is provided round the reactor pressure vessel.

(*c*) Secondary shield consisting of 3 to 4 ft. of concrete surrounds the primary loop equipment.

(*d*) Fuel vault for unused fuel elements.

(*e*) Spent fuel pit immediately adjacent to vapour container, into which spent fuel elements are transferred after removal from core for cooling off.

Secondary System

The secondary circuit follows conventional power station practice being variable to suit site conditions and the duty required. Typical data for a station with condensing turbine and bled steam for feed water heating are as follows:

Steam pressure at turbine	375 lb. per sq. in. gauge
Steam temperature	226 deg. C. (439 deg. F.)
Steam flow from steam generator	174,000 lb. per hr.
Feed water temperature	138 deg. C. (280 deg. F.)
Condenser pressure	2·5 in. Hg.
Turbo-alternator output (net sent out)	10 MW

Control System

The reactor control circuits are designed to provide safety under all operating conditions. The control rods are arranged to drop at 150 per cent. of design power, or if the reactor period becomes less than three seconds. The action is extremely fast and the control rods start to drop within about 60 milliseconds, and at an acceleration of 24 ft. per sec. per sec. The pressuriser is operated by electrical heaters regulated by a pressurestat. Pressure, temperature and water level in the pressuriser are all recorded in the control room as are the differential temperatures across the reactor. The primary coolant blow-down and make-up are recorded on the panel, and conductivity is recorded both before and after the demineralisers. The reactor shuts down on the following signals: pressure (high and low) in pressuriser, levels (high and low) in pressuriser, reactor outlet temperature (high), steam generator outlet pressure (high), steam generator outlet temperature (high), primary coolant flow (low), coincidence of two P.C.P. chambers, reactor period (short) and manual. Operational monitoring is provided at significant points to indicate immediately any abnormal operating conditions which might be hazardous to personnel either within or beyond control areas. All instruments actuate visual or audible alarms on the main control panel. Both the reactor control and the turbine and electrical control instruments are housed in the central control room.

South of Scotland Station: Novelties of Design

Further details have recently been released on the design of the atomic power station to be built by the G.E.C.—Simon-Carves Atomic Energy Group for the South of Scotland Electricity Board. The station was previously discussed in ENGINEERING on December 21, 1956, on page 794, where a diagram showing the reactor layout was reproduced. Work on the station, which will have an ultimate electrical output of 320 MW, is to begin during the first half of this year, and the first reactor is scheduled to become critical in 1960-61. The station will include a number of novel features not found in the Calder Hall station, some of which are outlined below. A table of design data is also given.

Flux Flattening.—There is a limit to the amount of heat which can be extracted from a fuel element. This limit is set by the heat transfer characteristics of the canning material, and by the flow of coolant. In order to increase the total heat output of the reactor without overheating the central channels, the neutron flux distribution (which directly governs the local heat output) is flattened so that as many channels as possible run at the maximum heat rating. The flattening is carried out by inserting neutron-absorbing stainless steel rods into a number of the central core channels; the flattening rods provide an artificial wastage of neutrons equal to the geometrical leakage in the outer portion of the core. As the fuel is burned up during operation the absorbing material is gradually removed and the flattening is finally achieved by using depleted uranium in the centre of the core. In this way a higher burn-up of the central fuel elements is attained. The maximum neutron flux in this region is approximately $2{\cdot}0 \times 10^{13}$ neutrons per sq. cm. per sec.

Gas Flow and Temperature.—In the outer region of the core, the moderator channel is reduced in diameter by increasing the thickness of the graphite tubes containing the fuel elements. By reducing the channel diameter the mass flow of coolant gas up the channel is decreased. This has the effect of keeping up the temperature of the fuel can, and, therefore, of the outlet gas. The outlet gas temperature from these outer channels, where the level of reactivity, and hence the fuel temperature, is lower than in the centre of the core, can thus be maintained at least at the level of the gas coming from the central core channels. Control of gas temperature is achieved by "gagging." Steel plates with central holes of varying diameter are mounted at the bottom of certain fuel channels outside the flattened region. The flow of gas up these channels can therefore be restricted, depending on the degree of gagging and gas outlets can be maintained at approximately constant temperatures.

Fuel Element Support.—Ten fuel elements constitute the complete charge for one vertical channel, and the method developed for their

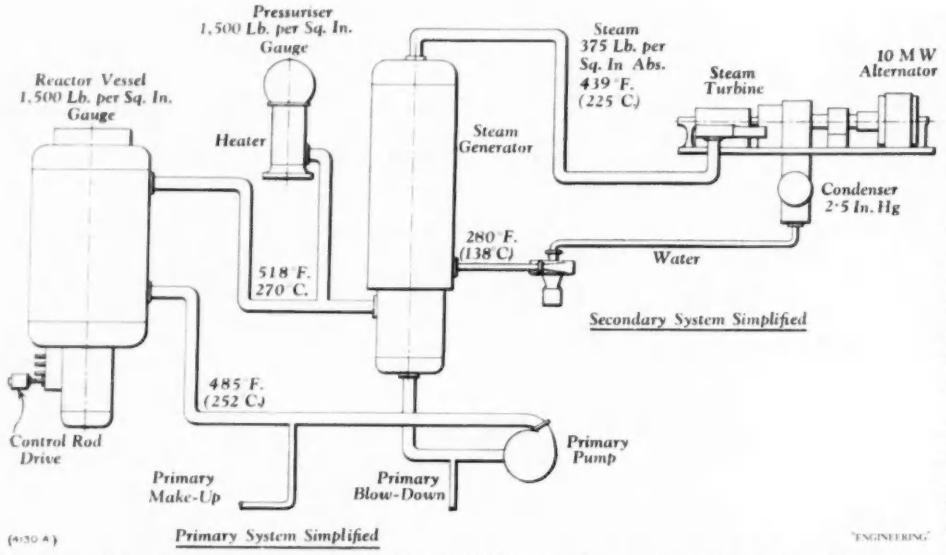


Fig. 2 Alco package power reactors based on APPR are of pressurised-water design (light water under pressure is used as coolant and moderator) and require enriched uranium fuel.

support—the G.E.C. replaceable channel fuel element—is of considerable interest. For ease of charge and discharge operations it is desirable that the fuel elements should be placed one on top of the other in the channel. On the other hand, this method imposes considerable stress on the lower elements in the channel because of the weight of uranium, and may lead to distortion by bowing. The G.E.C. system of fuel element support goes a long way towards meeting these conflicting considerations and confers in addition a number of other important advantages. The essential feature of the design is that each canned fuel element is individually supported and located by non-metallic " spiders " inside a relatively large bore graphite tube. The assembled fuel elements, each consisting of a fuel cartridge and a graphite sleeve, can be mounted one on the other within the fuel channel to achieve the desired combination of separately supported elements which are at the same time conveniently stacked for charge and discharge. Location of the tubes centrally in the main moderator channels is effected by small graphite lugs on the tubes and by a cup-and-cone arrangement of successive tubes. The main gas flow is up the bore of the graphite tube in direct contact with the fuel elements. In addition, a small quantity of gas is allowed to pass up the annular space between the graphite sleeve and the main moderator channel to extract the heat (about 6 per cent. of the total) generated by collision processes in the graphite itself. Other important advantages of the replaceable channel fuel element are as follows. 1. The smooth external shape of the graphite cylinder results in considerably less abrasion of the main channel during charge and discharge operations than would be the case if the fuel element itself, perhaps with metal spiders attached, had to be handled. 2. Reactions between the carbon dioxide coolant and graphite could lead to the formation and eventual mass transfer of free carbon. Should this effect become appreciable the affected graphite can readily be removed and replaced. 3. Without the replaceable channel, a bad fuel-can burst could lead to fission product contamination of the main moderator channels such that small increases in radioactivity due to subsequent bursts could no longer be detected. With the present design, however, there is every possibility that the contamination will be discharged with the faulty element and the moderator channel can continue to be used.

Double Pressure Vessel.—As stated in our previous article, the pressure vessel comprises two shells, an inner cylindrical shell to withstand the maximum gas temperature and an outer spherical shell to contain the full gas pressure. Further details will be given in a later article.

Control Rods.—There are altogether 208 channels in the reactor core structure which can be used for control rods, each control-rod channel being associated with 16 fuel channels. In practice, not all of these core channels will contain control rods. Access to the control-rod channels is obtained from above the reactor through tubes passing upwards from just above the core, through the inner and outer shells and the upper biological shield, terminating in a set of 208 larger diameter standpipes. Housed within each of the control-rod standpipes is the individual control-rod mechanism for that channel. The remaining standpipes are used to gain access to the fuel channels from above with the aid of the reactor servicing machine which will be described later. The control-rod mechanism, which is illustrated in Fig. 3, comprises a flexible stainless-steel wire rope wound on a conically shaped drum driven by a low-frequency permanent-magnet motor. Each control rod is moved in or out of the core by applying a 3 phase low-frequency supply to the motor stator; the rods are held out of the core by reducing the frequency of the supply to zero, that is a D.C. condition. The low-frequency supply is obtained from a motorised induction regulator uniquely connected with transformers and rectifiers. The control-rod motors are arranged in groups of 4, each group being coupled to the same low-frequency supply and the motors therein thus driven in synchronism. The low-frequency supply equipment is situated outside the biological shield. The stainless steel wire rope supporting the control rod passes through a small-bore hole in the centre of a long concrete shielding plug which is attached to the control-rod mechanism. The control rods themselves consist of a specially developed lightweight boron-containing material canned in a thin stainless-steel sheath. Short lengths assembled in this way are then placed within the main control-rod tube. The completed control rod is 21 ft. long and 2 in. in diameter. The control rods are divided into four groups—two coarse control, a fine control and a safety group. The two coarse groups are capable of a combined reactivity control of 4·85 per cent. The fine group controls 0·4 per cent. reactivity and the safety group 1·25 per cent. In the event of an emergency all the control-rod motor stators are de-energised simultaneously by cutting off the power supply and the four groups of rods fall into the core under gravity. The rods initially accelerate until they are well into the core but towards the end of their travel a braking force is applied so that their final velocity is low. This characteristic is governed by the conical shape of the winding drum and the impedance of the closed winding in the stator. During operation of the reactor the position of each control rod is detected by a synchro-transmission system coupled directly to the winding drum. Slack or overtaut rope is also detected.

Reactor Servicing Machine.—The reactor servicing machine takes the form of a travelling pressure vessel situated above the upper biological shield of the reactor. We hope to describe it in greater detail in a later issue.

Technical Data for G.E.C. Station

The design data for the station to be built in the South of Scotland by G.E.C.-Simon-Carves are as follows.

Fuel

Material	Natural uranium rods
Diameter of rod	1·15 in.
Length of rod	24 in.
No. of rods per channel	10
No. of rods per reactor	32,880
Wt. of uranium per rod	7·64 kg. (16·8 lb.)
Wt. of uranium per reactor	251 tonnes

Method of Support

The cartridge is individually supported in a graphite tube which is charged and discharged with the fuel element. The graphite tubes are stacked in the channel so that weight loads are not borne by the cartridges.

Moderator and Reflector

Material	Graphite
Core dia.	44 ft. 6 in. (50 ft. 6 in. with reflector)
Core length	23 ft. 0 in. (28 ft. 0 in. with reflector)
Arrangement of fuel channels	Vertical
Total number of fuel channels per reactor	3,288
No. of control rods channels per reactor	208
Diameter of control rod channels	3·5 in.
Type of lattice	Square
Lattice pitch	8¼ in.
Total weight of machined graphite per reactor	2,150 tons

Graphite support: Steel plate on steel grid made up from plates 7 ft. deep.

Nuclear Data

Maximum thermal neutron flux in uranium	$2·0 \times 10^{13}$ neutrons per sq. cm. per sec. approx.

Method of flattening: steel bars replacing fuel elements

Total built-in excess reactivity at start-up (reactor cold)	4·57 per cent. in k
Average initial conversion factor	0·800

Spherical Pressure Vessel

Material	Coltuf 28
Shape and dimensions	70 ft. internal diameter sphere
Thickness of shell	general, 2¼ in. support course, 3 in.
Maximum internal working pressure	150 lb. per sq. in.
Wt. of gas in vessel under operating conditions	41·4 tons
Maximum shell temperature	450 deg. F. (232 deg. C.)

Inner Shell

Boiler plate: cylindrical sides, domed top.

Control Rods

Material: boron, containing inserts canned in thin stainless-steel sheet and packed in tubular stainless-steel control rods.

No. of rods per reactor		150
Dimensions of rod		length, 21 ft. 0 in. diameter, 2 in.
Wt. of rod		70 lb.
Control rod grouping:	shut-off group	1·25 per cent. in k
	fine control group	0·4 per cent. in k
	two coarse groups	4·85 per cent. in k
Total reactivity controlled		6·5 per cent. in k

Biological Shield

Material	reinforced concrete
Thickness	9 ft. 0 in. walls, 10 ft. 6 in. roof

Shield cooling: once through forced and induced draught air cooling, air flow being directed over or through concrete walls.
Concrete specification.

Reactor Design Performance

Gas temperature at reactor inlet	240 deg. C. (464 deg. F.)
Bulk gas temperature at reactor outlet	396 deg. C. (745 deg. F.)
Gas pressure at reactor inlet	150 lb. per sq. in. gauge
Gas pressure at reactor outlet	145·8 lb. per sq. in. gauge
Mean fuel rating	2·11 MW per tonne
Total gas flow rate	5,640 lb. per sec.
Heat transferred to gas from reactor	530 MW
Heat transferred from gas in steam raising units	540 MW

Carbon Dioxide System

Main Circulators

Type	Vertical shaft, centrifugal
No. per reactor	8

Type of drive: D.C. motors supplied from grid controlled rectifier

Outlet gas pressure	150·5 lb. per sq. in.
Gas pressure rise across circulator	7·5 lb. per sq. in.
Circulator input	2,190 b.h.p.
Electrical power consumption per reactor	12·6 MW
Running speed	1,000 r.p.m.

Method of speed control: grid-controlled mercury-arc rectifier

Range of speed control	10 to 1

Main Ducts

No. of ducts per reactor	8 inlet, 8 outlet
Duct diameter	5 ft.
Gas transit time round circuit	23 sec.

Steam Raising Units

No. per reactor	8

Per Steam Raising Unit

Total gas volume	18,000 cu. ft.
Total wt. of gas under operating conditions	5·2 tons
Inlet gas temperature	396 deg. C. (745 deg. F.)

Outlet gas temperature	200 deg. C. (392 deg. F.)
High-pressure steam flow	143,000 lb. per hr.
High-pressure steam pressure	575 lb. per sq. in. gauge
High-pressure steam temperature	370 deg. C. (700 deg. F.)
Low-pressure steam flow	69·5 k. lb. per hr.
Low-pressure steam pressure	145 lb. per sq. in. gauge
Low-pressure steam temperature	354 deg. C. (670 deg. F.)

Turbo-generators

No. of sets per station	6
Type	Multi-stage, axial flow, impulse reaction
Continuous maximum rating per set	60 MW
Cooling hydrogen at 30 lb. per sq. in. gauge	
Speed	3,000 r.p.m.
Generator voltage	11·8 kV
Power factor at C.M.R.	0·8
Steam pressure at high-pressure stop valves	555 lb. per sq. in. gauge
Steam pressure at low-pressure stop valves	135 lb. per sq. in., gauge
Steam temperature at high-pressure stop valves	366 deg. C. (690 deg. F.)
Steam temperature at low-pressure stop valves	349 deg. C. (660 deg. F.)
High-pressure steam flow per set	382 k. lb. per hr.
Low-pressure steam flow per set	186 k. lb . per hour
Final feed temperature at C.M.R.	146 deg. C. (296 deg. F.)

Steam Dumping Equipment

Two condensers per station, operating at atmospheric pressure with spray de-superheaters. Steam released to dump through automatic pressure-controlled valves.

Problem Sites

The interminable opposition to the siting of nuclear power stations continues. Although G.E.C.—Simon-Carves are ready to proceed on the South of Scotland station, the official inquiry at which 33 parties have raised objections to the use of Hunterston as a site is likely to delay the commencement of work. Other sites which had been considered were given as Roseneath, Ardgowan, Knock Castle, Blackrock Point, Portencross, West Kilbride and Lunderston, but Hunterston was regarded as the ideal choice.

Possible sites for nuclear power stations are also being investigated in Wales; borings are being made to establish the suitability of the subsoil on the west coast and in particular in Cardiganshire. Welsh M.P.s have been appealing to the Central Electricity Authority to consider the claims of Wales in the planning of the future nuclear power programme. There appear to be good prospects.

It has also been reported that an atomic development and research centre, similar in some respects to Harwell, with a staff of 2,000 (600 specialists), is to be established near Talsarnau, Merioneth, on an 800 acre site.

Insurance

Last week we drew attention to the work being carried out on the problem of insurance in the atomic field. Since then it has been announced that overall insurance cover for atomic power stations, (which cost in the region of £35 million) and for third party risks can be arranged through the British Insurance (Atomic Energy) Committee, which has been formed under the auspices of the British Insurance Association and Lloyd's to represent the whole British insurance market for atomic energy. It appears that the United Kingdom is prepared to handle higher liability limits than the 50 million dols. (nearly £18 million) maximum for any claim for one accident said to have been set by the American insurance groups.

A Nuclear Insurance Rating Bureau has been established in New York as part of the machinery for dealing with insurance problems in the atomic energy field. Representing more than 300 stock and mutual insurance companies, the bureau, when licensed by the various States, will have rating jurisdiction over nuclear risks underwritten by its members, all of which are associated with either the Nuclear Energy Property Insurance Association or the Mutual Atomic Energy Reinsurance Pool. Risks to be rated include nuclear reactor power plants and other reactor installations, fuel-element plants, nuclear fuel and certain other facilities involving substantial quantities of radiation. Through the stock and mutual association already organised, more than 50 million dollars is available for such risks.

Electromagnetic Separator

HERMES, a new electromagnetic separator for sorting a mixture of different isotopes, has recently begun to operate at Harwell. Its name is derived from the full title: heavy element and radioactive material electromagnetic separator. Groups of atoms which are chemically identical are separated from one another in the machine by accelerating a beam of ionised atoms through regions where electrical and magnetic forces cause groups of them differing slightly in weight to follow different paths through the machine. There are two other electromagnetic separators at Harwell. The purpose of HERMES is to separate single radioactive isotopes. The machine and its ancillary equipment is thus specially designed to handle highly toxic and radioactive materials. It is the largest and most complex machine in Western Europe yet built into a sealed space. In effect, it is enclosed in a glove box (a device in which poisonous and radioactive materials can be handled in complete safety). Servicing and maintenance of the machine is carried out by skilled frogmen in heavy rubber suits, who enter through a corridor. The sealed building in which the separator is enclosed is 21 ft. by 25 ft. and 14 ft. high. The machine is operated from a nearby control room. Investigation of the fundamental nuclear properties of separated radioactive isotopes is of great importance, not only in extending our knowledge of nuclear physics, but also in providing data often vital for the development of advanced reactor technology. HERMES will be used, for example, to assist the precise measurement of the nuclear properties of the various types of plutonium which may be generated in a nuclear reactor. It is capable of separating isotopes of plutonium in milligram range quantities, and may be used to separate radioactive isotopes of other elements. The new machine was designed and constructed at the Atomic Energy Research Establishment from equipment supplied by some 20 contractors.

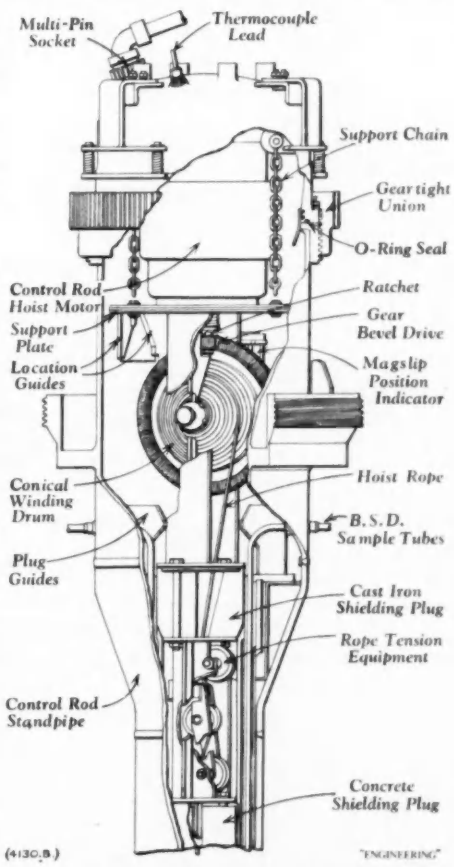


Fig. 3 Diagram of control rod mechanism for nuclear power station to be built by G.E.C.—Simon-Carves Atomic Energy Group for the South of Scotland Electricity Board.

Reactor Rejects

The U.S. Atomic Energy Commission has determined that three of seven proposals to develop, design, construct, and operate small-capacity nuclear power plants which were submitted in response to the second invitation of the Power Development Reactor Programme are not acceptable as a basis for negotiation of contracts for Commission assistance. Contract negotiations are in progress for assistance requested under the four other proposals. The Power Demonstration Reactor Programme is designed to bring resources other than those of the Federal Government into the development of reactor technology and to advance the time when nuclear power reactors will become economically competitive. The proposals which have been determined to be unacceptable are those of the City of Holyoke, Massachusetts, the City of Orlando, Florida, and the University of Florida.

The City of Holyoke, jointly with the Ford Instrument Company, a subsidiary of Sperry-Rand Corporation, proposed a gas-turbine plant of 12,650 kW (electrical) capacity to be powered by nitrogen circulating as coolant through the reactor. The Commission determined that the planning of a power plant based on the proposed reactor system is premature because the basic feasibility of the concept has not yet been demonstrated. The gas-cooled reactor experiment recently undertaken by the Commission and other research and development work under way in the Commission's programme are expected to provide the basic information needed before the research and development for a full-scale nuclear power plant can begin.

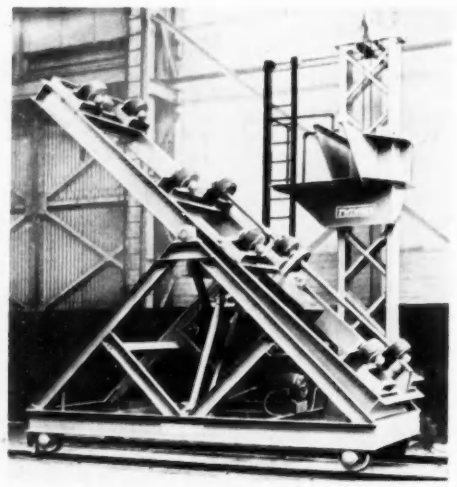
The City of Orlando proposed a liquid metal fuelled reactor plant of 25 to 40 MW (electrical) capacity. The Commission determined that, as in the case of the Holyoke proposal, the technical feasibility of the proposed Orlando plant has not yet been established and that research and development of undetermined scope and cost will be necessary before the planning of a full-scale power plant can be undertaken. The Commission's programme of research and development on the liquid-metal fuelled concept includes a reactor experiment which is expected to be in operation in 1959.

The University of Florida proposed a pressurised light water reactor which would power a turbine-generator of about 500 kW capacity and would be used principally in research, testing and training. The Commission determined that this proposal does not qualify as a power demonstration reactor project in that it would make only minor contributions to the demonstration of the economic generation of electricity while placing emphasis on use of the reactor for the research, testing and training purposes.

Negotiations are under way for varying forms of assistance based on the four other proposals made to the Commission in response to the second invitation of the Power Demonstration Reactor Program. These proposals are: (1) Rural Co-operative Power Association of Elk River, Minnesota—a closed-cycle boiling-water reactor plant of 22 MW (electrical) capacity; (2) Wolverine Electric Co-operative of Big Rapids, Michigan —an aqueous homogeneous reactor plant of 5 to 10 MW (electrical) capacity; (3) Chugach Electric Association of Anchorage, Alaska, and the Nuclear Development Corporation of America, White Plains, New York—a heavy-water moderated, sodium-cooled reactor plant with 10 MW (electrical) capacity; and (4) City of Piqua, Ohio—an organic-moderated plant of 12·5 MW (electrical) capacity.

Post Graduate Course

A post graduate residential course of 16 lectures in the "Basic Principles of Nuclear Engineering" is being held from April 7 to 13, 1957, by the University of Liverpool Department of Extra-Mural Studies. The course is intended for qualified engineers with no specialised knowledge of physics, and inquiries should be made to the Director of the Department, at the University, Abercromby-square, Liverpool 7. A similar course is being held on "Tensor Analysis Applied to Electrical Engineering."



A "Twinner" tilting and turning roll assembly can be combined with an adjustable welding-head manipulator to cover a large range of work.

TILTING AND TURNING FOR WELDING

The new "Twinner" tilting and turning roll assembly, made by Donald Ross and Partners, Limited, Gatwick-road, Crawley, Sussex, has been designed to combine the functions of the makers' standard rolls with tilting to 45 deg. for fillet welding of stiffening rings and other circumferential fitments. Tilting is possible to 45 deg.

The illustration shows a set of manually-propelled tilting turning rolls rated for a safe working load of 10 tons. Hydraulic rams are used to tilt the roll bed both ways. There are three driven rollers on one side of the bed and three idle rollers opposing them on the other side. A pair of idle rollers at the end of the bed is adjustable longitudinally relative to the driven rollers. End-thrust rollers support the ends of cylinders being fabricated when the bed is tilted. All the roller assemblies have the makers' patented steel overload discs on each side of a rubber tyre, which gives maximum traction but does not permit the tyres to deform to a point at which they would wear or suffer damage. The load-bearing capacity of the rollers is high, but they only require a narrow path on the component being welded, a feature which can be important when there are parts welded on the outside. Single or variable-speed gear for rotating the rollers can be supplied, and the trolley can be either power-operated or manually worked.

Also visible in the illustration is a "Twinner" automatic welding-head manipulator. This is one of a series designed to provide a rigid but adjustable boom for carrying the welding head. In the model shown, the boom is raised and lowered by a power-operated winch, and can be used at any height between 3 ft. and 16 ft. from floor level. An operator's platform, complete with guard rails, is incorporated in the boom. The manipulator is designed, as may be seen from the illustration, for external longitudinal and circumferential welding, but a variation of the design is available for internal welding.

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ENGINEERING DISTRIBUTORS

Speaking at a Council luncheon of the Association of Engineering Distributors, on January 29, Mr. L. Henshaw, director of Nuckey, Scott and Company, Limited, stressed the importance of manufacturers and distributors working together and making the utmost use of technical sales services. He also announced that, as from January 31, the Ground Thread Tap Association and the Cut Thread Screwing Tool Manufacturers' Association would disappear, the Screw Thread Tool Manufacturers' Association and the Screw Thread Tool Manufacturers' Export Association coming into being in their place.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Light Sources," by G. V. McNeill. Central London Branch. White Hall Hotel, Bloomsbury-square, W.C.1. Mon., Feb. 11, 7.30 p.m.

BOURNEMOUTH
"Theory of Atomic Energy and Its Industrial Application," by Dr. J. H. Fremlin. Bournemouth Branch. Grand Hotel, Firvale-road, Bournemouth. Tues., Feb. 12, 8 p.m.

OXFORD
"Fluorescent Circuits and Servicing," by G. V. McNeill. Oxford and Reading Branch. Regents Park College, Pusey-street, Oxford. Sat., Feb. 16, 6.30 p.m.

Birmingham Exchange and Engineering Centre

BIRMINGHAM
"Turbo Car Progress," by P. A. Phillips. Thurs., Feb. 14, 6.30 p.m. (Admission by ticket.)

British Institution of Radio Engineers

GLASGOW
"The Earth Satellite Project," by P. H. Tanner. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Feb. 14, 7 p.m.

LIVERPOOL
"Radioactivity and Its Measurement," by E. W. Pulsford. Merseyside Section. Chamber of Commerce, 1 Old Hall-street, Liverpool 3. Thurs., Feb. 14, 7 p.m.

WOLVERHAMPTON
"An Automatic System for Electronic Component Assembly," by K. M. McKee. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Feb. 13, 6 p.m.

Building Centre

LONDON
Film "The Titanium Pigment Story," exhibited by British Titan Products Co. Ltd. Wed., Feb. 13, 12.45 p.m.

Chemical Engineering Group

LONDON
"Some Aspects of British Standards in Relation to Chemical Engineering in the Chemical Industry," by D. E. B. Greensmith. Society of Chemical Industry, 14 Belgrave-square, S.W.1. Tues., Feb. 12, 5.30 p.m.

Chemical Society

LONDON
"The Course of Polar Reactions in Non-Polar Conditions," by Professor C. K. Ingold. Royal Institution, Albemarle-street, W.1. Thurs., Feb. 14, 7.30 p.m.

BRISTOL
"Free-Radical Chemistry—A Survey," by Professor D. H. Hey. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Feb. 14, 7 p.m.

EDINBURGH
"Lead Tetraethyl as an Engine Anti-Knock," by Professor A. D. Walsh. Edinburgh Branch. Pharmaceutical Society, York-place, Edinburgh. Thurs., Feb. 14, 7.30 p.m.

Helicopter Association of Great Britain

LONDON
"Vibration Problems Associated with the Helicopter" by O. L. L. Fitzwilliams. 4 Hamilton-place, S.W.1. Tues., Feb. 12, 7 p.m.

Illuminating Engineering Society

LONDON
Trotter-Paterson Memorial Lecture: "Some Experiments in the Interference of Waves," by Sir Lawrence Bragg. Royal Institution, Albemarle-street, W.1. Mon., Feb. 11, 6 p.m.

HULL
"Glassware for Artificial Lighting," by D. Keenan. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Mon., Feb. 11, 7 p.m.

Incorporated Plant Engineers

BRISTOL
"More Effective Use of Semi-Skilled Labour," by E. Strong. Western Branch. Grand Hotel, Bristol. Wed., Feb. 13, 7.15 p.m.

DUNDEE
"Experiences in Shipbuilding," by J. Liddle. Dundee Branch. Mathers Hotel, Dundee. Mon., Feb. 11, 7.30 p.m.

LIVERPOOL
"Warehouse Handling, with Particular Reference to Unit Loads," by J. G. Boyne. Merseyside and North Wales Branch. Exchange Hotel, Liverpool. Thurs., Feb. 14, 7.15 p.m.

NOTTINGHAM
"Boiler House Management: Coal and Oil-Fired Shell and Tubular Boilers," by O. H. Barker. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Feb. 13, 7 p.m.

Institute of Fuel

LONDON
"The Rise of a Hot Waste Gas Plume," by C. H. Bosanquet; and "Maximum Gas Concentration at Ground Level from Industrial Chimneys," by A. C. Best. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Feb. 13, 5.30 p.m.*

Institute of Marine Engineers

LONDON
"Boiler Feed Water Treatment for Advanced Steaming Conditions," by J. Leicester; and two papers on "Corrosion in Scotch Marine Boilers," by Dr. F. Wormwell, Dr. G. Butler, J. G. Beynon and H. C. K. Ison. Tues., Feb. 12. 5.30 p.m.*

BIRKENHEAD
"Modern Marine Steam Turbines," by J. H. Gooch. Junior Lecture. Merseyside and North Western Section. Technical College, Birkenhead. Wed., Feb. 13, 7.15 p.m.

BRISTOL
"Marine Lubrication," by G. H. Clark. West of England Section. Grand Hotel, Bristol. Mon., Feb. 11, 7.30 p.m.

Institute of Metals

BIRMINGHAM
"Modern Developments in Forging, Rolling and Extrusion," by Professor A. R. E. Singer. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Feb. 14, 6.30 p.m.

SWANSEA
"Neutron Irradiation Effects in Metals," by Professor J. G. Ball. South Wales Local Section. University College, Singleton Park, Swansea. Tues., Feb. 12, 6.45 p.m.*

Institute of Physics

LONDON
"Acoustics in Non-Destructive Testing," by Dr. R. W. B. Stephens. Non-Destructive Testing Group. Fri., Feb. 15, 6.30 p.m.*

Institution of British Agricultural Engineers

LONDON
"Jungle Clearance and Reclamation," by C. S. L. Frances. Tues., Feb. 12, 5.30 p.m.*

Institution of Civil Engineers

LONDON
"Employment of Contractor's Plant on Civil Engineering Construction Works," by R. H. McGibbon and J. H. Brass. Works Construction Division. Tues., Feb. 12, 5.30 p.m.*

BIRMINGHAM
"Prestressed-Concrete Runways: History, Practice and Theory," by A. J. Harris. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Feb. 14, 6 p.m.

MIDDLESBROUGH
"Railway Modernisation and Re-equipment: Some Civil Engineering Works and Problems Involved," by Arthur Dean. Northern Counties Association. Cleveland Scientific and Technical Institution, Middlesbrough. Wed., Feb. 13, 6.15 p.m.

Institution of Electrical Engineers

LONDON
"The Ultimate Performance of the Single-Trace High-Speed Oscillograph" and "The Design and Performance of a New Experimental Single Transient Oscillograph with Very High Writing Speed," by M. E. Haine and M. W. Jervis. Joint meeting of Measurement and Radio Sections. Tues., Feb. 12, 5.30 p.m.*
Faraday Lecture "Nuclear Energy in the Service of Man," by Dr. T. E. Allibone. Central Hall, Westminster, S.W.1. Wed., Feb. 13, 6 p.m. (Admission by ticket, gratis.)
"Self-Compensated Alternators," by P. J. Bhatt; "The Metal Rectifier and Its Importance to the Electrical Engineer," by D. Mangnall; and "The Automatic Factory," by G. F. Stewart. Utilization Section. Thurs., Feb. 14, 5.30 p.m.*

BELFAST
"Electronics and Automation," by Dr. H. A. Thomas. Northern Ireland Centre. Engineering Department, Queen's University, Belfast. Tues., Feb. 12, 6.30 p.m.

NEWCASTLE-UPON-TYNE
"Engineering Efficiency, Economics and Expediency," by

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham 2. (Midland 1914.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Metallurgical Society, Greenhithe, Grosvenor-road, St. Helens, Lancs. (St. Helens 5879.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)

P. J. Ryle. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Feb. 11, 6.15 p.m.
SOUTHAMPTON
Faraday Lecture on "Nuclear Energy in the Service of Man," by Dr. T. E. Allibone. Southern Centre. Guild Hall, Southampton. Mon., Feb. 11, 6.30 p.m.

Institution of Engineers-in-Charge

LONDON
"Materials Handling and Stores Control," by A. J. Cross. St. Bride Institute, Bride-lane, E.C.4. Wed., Feb. 13, 6.30 p.m.*

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Electronics and Engineering," by Dr. D. S. Gordon. Tues., Feb. 12, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"The Manufacture and Applications of Forced Air Heaters," by G. L. Johnson. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Feb. 12, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
A series of short papers on engine detail components. Automobile Division. Tues., Feb. 12, 6 p.m.*
Thomas Hawksley Lecture on "Some Engineering Problems in the Industrial Development of Nuclear Energy," by Sir Claude Gibb. Church House, Westminster, S.W.1. Fri., Feb. 15, 6 p.m. (Admission by ticket.)
CHATHAM
"Overdrives," by S. H. Ashby. Southern Branch. Star Hotel, Chatham. Wed., Feb. 13, 7.15 p.m.
LIVERPOOL
Thomas Lowe Gray Lecture on "The Salvaging of Ships, with Particular Reference to the Empress of Canada," by Captain W. R. Colbeck. North Western Branch. 9 The Temple, 24 Dale-street, Liverpool. Wed., Feb. 13, 6 p.m.

Institution of Production Engineers

LONDON
"Design and Production of Die Castings in Zinc Base and Aluminium Alloys," by P. A. R. Findlay. London Graduate Section. Wed., Feb. 13, 7.15 p.m.
DONCASTER
"Invention Can Become a Habit," by G. Jackson. Doncaster Section. Danum Hotel, Doncaster. Tues., Feb. 12, 7 p.m.
EDINBURGH
"Work at Leith Docks," by M. C. White. Edinburgh Section. North British Hotel, Princes-street, Edinburgh. Wed., Feb. 13, 7.30 p.m.
SHEFFIELD
"Continuous Casting," by I. M. D. Halliday. Sheffield Section. Grand Hotel, Sheffield. Mon., Feb. 11, 6.30 p.m.

Institution of the Rubber Industry

LONDON
"Different Types of Heating in the Rubber Industry," by J. R. Happer, at 5.30 p.m.; and "Dipped Goods Processing and Production," by S. D. Sutton, at 7 p.m. 26 Portland-place, W.1. Tues., Feb. 12.

Institution of Structural Engineers

LONDON
"Post-War Developments in German Steel Bridges and Structures," by G. B. Godfrey. Thurs., Feb. 14, 6 p.m.
LIVERPOOL
"Welded Steel Structures," by A. V. R. Hooker. Lancashire and Cheshire Branch. College of Building, Liverpool. Wed., Feb. 13, 6.30 p.m.
MANCHESTER
"Welded Steel Structures," by A. V. R. Hooker. Lancashire and Cheshire Branch. College of Technology, Manchester. Thurs., Feb. 14, 6.30 p.m.

Junior Institution of Engineers

LONDON
"Application of Pneumatic Controllers to Automatic Process Control," by G. A. Wapling. Fri., Feb. 15, 7 p.m.*

Liverpool Metallurgical Society

LIVERPOOL
"Work Hardening and Dislocation Theory," by Dr. A. H. Cottrell. 9 The Temple, 24 Dale-street, Liverpool. Thurs., Feb. 14, 7 p.m.

Newcomen Society

LONDON
"The Staunches and Navigation of the Little Ouse River," by Ronald H. Clark. Wed., Feb. 13, 5.30 p.m.

Reinforced Concrete Association

LONDON
"Some Experiments with Concrete," by E. H. Bate. 11 Upper Belgrave-street, S.W.1. Wed., Feb. 13, 6 p.m.*

Royal Society of Arts

LONDON
"Development and Use of Glass Fibres," by A. Hudson Davies. Wed., Feb. 13, 2.30 p.m.

Royal Society of Health

LONDON
"Sanitary Installations and Appliances," by Alister MacDonald. Caxton Hall, off Victoria-street, S.W.1. Wed., Feb. 13, 2.30 p.m.

Royal Statistical Society

GLASGOW
"Measuring the Development of Reliability in Machines," by Dr. G. Morris. Glasgow Industrial Applications Group. 39 Elmbank-crescent, Glasgow, C.2. Thurs., Feb. 14, 7.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Radioactive Isotopes in Industrial Research," by Dr. D. H. Houseman. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield 3. Tues., Feb. 12, 7 p.m.

Society of Instrument Technology

LONDON
Annual Meeting of Control Section. "A Servo Speed-Control for a Camera Crane," by K. G. Crack. 26 Portland-place, W.1. Thurs., Feb. 14, 6 p.m.

South Wales Institute of Engineers

CARDIFF
"Design, Construction and Performance of Battery Mining Locomotives," by Colin L. Forbes. Thurs., Feb. 14, 6 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
"Heat, Fuel and Power Balances in an Integrated Steelworks," by J. A. C. Cowan and J. Roberts. Fri., Feb. 15, 6.45 p.m.*

DIAPHRAGM COMPRESSOR

Nylon-laminated Neoprene Fittings

A twin-cylinder diaphragm compressor, capable of continuous operation at 50 lb. per sq. in., has been developed by the Hymatic Engineering Company, Limited, Redditch, Worcestershire. It is shown in the accompanying illustration. To provide contamination-free air, multi-ply high-temperature neoprene diaphragms laminated with nylon are used. Unlike the smaller Hymatic compressors, the DP.14 is also suitable for closed-circuit applications, as both delivery and suction valves are located on the same side of the compression diaphragm. Of simple stainless-steel reed type, these valves are identical.

During testing it was found that maximum diaphragm life could be obtained by imparting straight line motion to the central connecting point of the diaphragm and this has been achieved in practice by using a scotch crank and slipper mechanism. The large bottom end and main bearings are lubricated by a splash system, an additional advantage being the heat dissipation from the back of the diaphragm through the oil with which it comes in direct contact. A fan is also fitted to the V-belt pulley to direct a cooling air flow across the finned crankcase and cylinder heads.

Free air delivery at 1,500 r.p.m. ranges between 7 cub. ft. per minute at 45 lb. per sq. in. and 9 cub. ft. per minute at 10 lb. per sq. in., the horse-power requirements for the belt drive being not more than 1·5. The compressor can be supplied integrated with a 400/440 volt three-phase electric motor. A clutch or Venturi-type unloader can be fitted for starting against load. Aluminium alloy is used for both crankcase and cylinder head castings, while cast iron and phosphor bronze are used for the scotch crank and slipper mechanism. Ball and roller bearings are used on the high-tensile steel crankshaft, the size of all bearings being sufficiently large to permit continuous operation over long periods. The DP.14 weighs 39 lb. and with fan attached, it measures 11 in. by 12 in. by 9 in.

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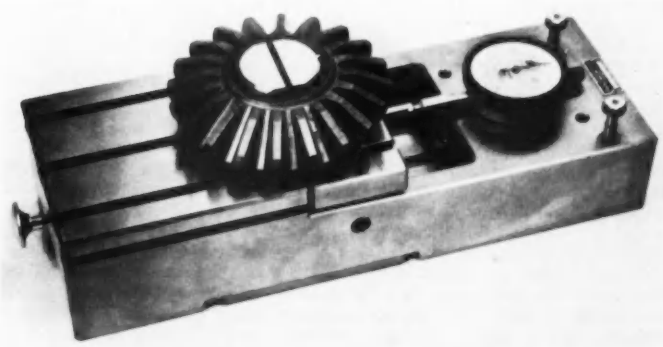
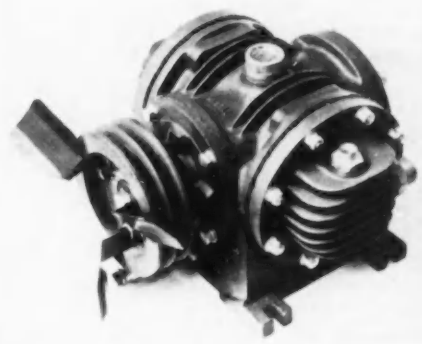
BENCH COMPARATOR

A precision bench comparator for general use has been introduced by British Indicators, Limited, Sutton-road, St. Albans, Hertfordshire. It is shown in the accompanying illustration. The main body is a rigid box-section casting on which is mounted a standard "John Bull" frictionless transmission unit. The top table of the transmission unit and the top table of the comparator frame are ground with each other in one plane, and through both run three longitudinal T-slots. The anvils are secured by means of these slots, the sensitive anvil being mounted on the table of the transmission unit, while the fixed anvil is mounted on the table of the frame.

When in use the transmission is in contact with the dial indicator by means of an adjustable datum stop. Suitable gauging pressure is provided by a tension spring, provision being made for the reversal of pressure when changing from external to internal checking. The sensitive anvil is retracted by means of a limit knob which restricts the travel of the transmission table in one direction. During the interchange of anvils, a pair of keeper pins are used to anchor the sensitive table to prevent damage to the transmission unit.



Precision comparator for both internal and external work. It is shown here set up for checking the effective diameter of the splined bore of a bevel gear.



This twin-cylinder diaphragm air compressor gives continuous operation up to 50 lb. per sq. in.

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RUBBER FOR PRECISION COMPONENTS

The Reliance Rubber Company, Limited, Cleveland-road, Hemel Hempstead, Hertfordshire, have recently extended their activities from the manufacture of domestic hot water bottles (of which their output now exceeds 1,600,000 a year) to that of "mechanised" rubber products. This term includes the many types of components now used in such industries as radar, electronics, aircraft and optics, involving work to tolerances of ± 0·005 in. With a soft flexible material like rubber such tolerances can be regarded as very exacting and the production of precision equipment from it requires a full understanding of the chemical and physical properties of the material under a variety of conditions.

An example of such products is a poppet valve made from a compound which is 90 per cent. pure rubber and is very soft and pliable. Owing to the purpose for which it is used it was necessary to mould the round head so that it was true within 0·0025 in. This is obviously a close limit to which to adhere in an article which is already very thin and which is made from such a pure mix.

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METALLOGRAPHY IN AUSTRIA

A lecture—"Recent Developments in Austria in the Field of Metallurgy"—will be delivered on Monday, February 25, at 6.30 p.m., at the Austrian Institute, 28 Rutland-gate, London, S.W.7, by Professor R. Mitsche, of the Leoben School of Mines. A small exhibition of equipment relating to the subject of the lecture is also to be held.

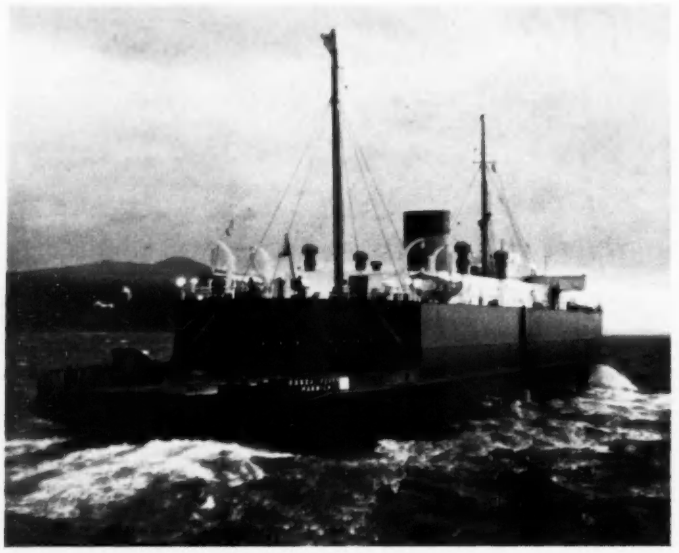

Fig. 1 Twin-screw motorship " Essex Ferry " of 3,242 gross tons, capable of accommodating 36 to 38 railway wagons.

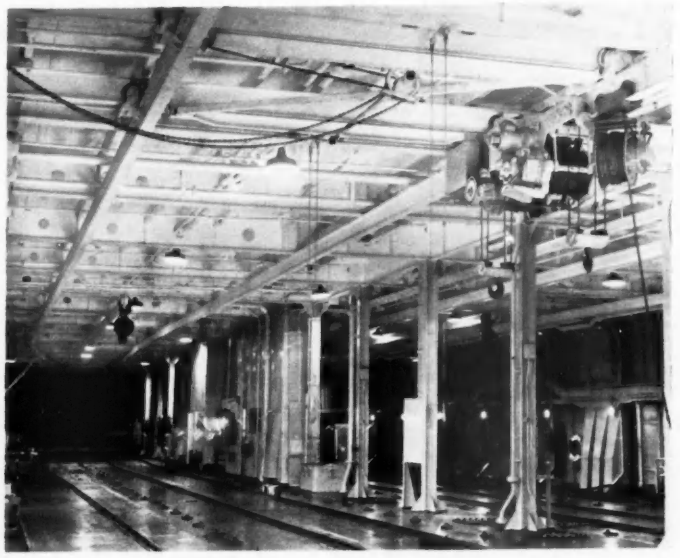

Fig. 2 Car deck of the vessel, showing electrically operated cargo handling gear.

NEW RAIL FERRY FOR HARWICH-ZEEBRUGGE SERVICE

The rail ferry service operated by the British Transport Commission between Harwich and Zeebrugge, being for the carriage of freight trains only, is not so well known, perhaps, to the general public as the passenger services across the Channel, but it is one of the most important links with Europe, especially for the transport of foodstuffs and other goods for which it is desirable to minimise intermediate handling. The advantages of being able to send such goods straight through by rail from, say, Italy or the south of France to the distributing centres in England are very real and have been much appreciated by shippers since the service was inaugurated in 1924 with three vessels which had been constructed for military purposes during the first World War, when they were used for the conveyance of Army stores from Richborough.

These three ships were again employed for war work during the second World War, two being sunk. The service from Harwich was resumed in August, 1946, with the surviving vessel, which was named Essex Ferry, and a second, the Suffolk Ferry, was ordered from John Brown and Company, Limited, Clydebank. She was delivered in the following year. The traffic continuing to grow, a third vessel was ordered in 1951; this was the Norfolk Ferry, also built and engined by John Brown and Company. The same firm handed over to the British Transport Commission last month the latest vessel for this service, the new Essex Ferry, which replaces the original ship of that name, now 40 years old. She is still a serviceable craft, however, and is being retained as a standby vessel, under the name of Essex Ferry II.

The new Essex Ferry, an exterior view of which is seen in Fig. 1, is similar in general design to the Norfolk Ferry, but has a slightly greater gross tonnage, 3,242 tons as against 3,157. The net register tonnage is also proportionately increased, from 1,408 to 1,502 tons. The vessel is 380 ft. long between perpendiculars, 58 ft. 6 in. moulded breadth and 35 ft. 6 in. moulded depth to the upper deck. There are four rail tracks with a total length of about 1,132 ft., which is sufficient to accommodate 36 or perhaps as many as 38 of the international rail-service wagons. There are only two loading tracks at the stern, but each of these branches into two. The two outer tracks total about 438 ft. and the inner, 694 ft. Electrically-operated cargo-handling gear is provided over all four tracks, so that containers can be transferred from wagons to the deck of the vessel, or loaded on to wagons. A view of the tracks and of the cargo handling gear is shown in Fig. 2. The trains are normally shunted on to the ferry and hauled off by locomotives, though the regulations are that these must not run on to the vessel's deck. The practice is, therefore, to interpose three or four additional wagons between the locomotive and the train. Trains, moreover, can be hauled on or off by the ship's own equipment if necessary, two electric capstans being fitted on the car deck.

Much of the space below the car deck is devoted to buoyancy tanks, there being one abaft the engine room and three forward. The after tank is separated from the engine room by a cofferdam; and between the engine room and the forward buoyancy spaces there are a 'thwartship fuel tank, a stores compartment, and a fresh-water tank. There are two longitudinal bulkheads.

The accommodation for the officers and crew, and for twelve passengers (the maximum permitted in a cargo vessel) is on the upper deck. At the forward end of the deckhouse are the captain's day and sleeping cabins, and the cabins of the chief officer and second officer. On the port side are those of the third officer, the radio officer, the chief engineer, and the four other engineer officers. On the starboard side is the accommodation for the passengers, in six two-berth cabins. Inboard, between the two fore and aft alleyways, are the offices of the chief engineer and the chief officer, and various bathrooms, stores, etc. Aft of the passengers' cabins, on the starboard side, is the dining saloon. The remainder of the space in the deckhouse is devoted to the quarters for the petty officers and crew, the galley, and the usual washplaces, oilskin lockers, etc. Ample provision is made, in both officers' and crew's quarters, for drying wet clothes.

The Essex Ferry is propelled by twin screws driven by two Brown-Sulzer engines developing collectively 3,200 h.p. The service speed is 13½ knots. The six-cylinder main engines follow standard Brown-Sulzer practice, with certain modifications; for instance, the fuel injection pumps are arranged to be accessible from starting-platform level and the flow of cooling oil to all cylinders is made visible, by a single light at the forward end of the engine which serves to illuminate all the sight glasses.

All the deck and engine-room auxiliaries are electrically driven, current being supplied by two 125 kW Diesel generating sets made by W. H. Allen, Sons and Company, Limited. The Reavell air compressors are driven by motors supplied by Laurence Scott and Electromotors, Limited. The various engine-room pumps are by Drysdale and Company, Limited; and the lubricating-oil system includes Serck coolers and Autoklean strainers. Brookhirst Switchgear, Limited, and Allen West and Company, Limited, were the contractors for the switchgear. An oil-fired Cochran boiler supplies heating steam.

The two 26 ft. lifeboats are carried at the after end of the upper deck in Welin-McLachlan davits. In addition to the ordinary equipment for wireless telegraphy, the vessel is provided with an echo sounder, Decca Navigator, and radar. The electric capstans, previously mentioned, are used for warping the vessel stern first into the terminal, where she is held in alignment with the shore tracks by a locking pin. The mean loaded draught of the ship is 12 ft. To compensate for variations in draught, according to the amount of freight, large trimming tanks are provided, the after tank holding 280 tons of water and the forward tank about 250 tons.

The Essex Ferry ran her trials on the Clyde on January 8 and 9, and when she was taken over, left immediately for Harwich by way of Land's End, a voyage of 800 miles on which, in spite of somewhat adverse weather, she proved to be an excellent sea boat. She arrived in Harwich on January 12 and took her first sailing to Zeebrugge on January 15.

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SEA MARKER LIGHTS

At the recent Boat Show at Olympia, London, were examples of Aqua Lights made by the McMurdo Instrument Company, Limited, Ashstead, Surrey. These are a series of lights, mainly for location purposes at night, which are not illumined until the driving cell is filled with water. The cells have an indefinite shelf life while they are sealed. Some units are designed to float when dropped in the water, as for instance, near a safety raft, and the cells have burning periods of up to 40 hours according to size and type. A particular one having a 40 hour period is designed for attachment to escape suits worn by submarine crews; activation occurs immediately it is immersed in water. The weight, complete with 16 in. of cable and the bulb housing, is approximately 5 oz. Some of the smaller models weigh as little as 0·7 oz. and give a burning time of 4 hours. These last will withstand being dropped into the water from an aircraft flying at 2,000 ft. There are also non-floating types which are able to withstand deep-water pressures and so can be used as under-water markers, or illuminants. There is one model designed especially for following the position of meteorological balloons.

In Parliament

OIL FROM AFRICA

Among the many technical and commercial problems which came before the House of Commons last week were some relating to the production and supply of oil. Mr. A. Fenner Brockway (Labour) suggested that very serious consideration should be given to the possibilities of developing oil supplies in Western Africa, in order to help in avoiding a repetition of the conditions which had now arisen in connection with supplies from the Middle East. He also inquired as to what information had been obtained from recent surveys regarding the feasibility of loading oil tankers by means of sea-loading submarine lines off the coast of the eastern delta of the River Niger.

Mr. Christopher Soames, the Parliamentary and Financial Secretary to the Admiralty, said that much information, such as that relating to the depth of water, the nature of the sea bed, tides, and weather had been collected about the area by the Admiralty survey vessel Owen during a recent surveying expedition. The information had been made available to Shell Tankers Limited, on whose behalf the survey had been made, and it was for that firm to assess whether the project for loading oil tankers was feasible.

It was understood that oil had been found at Oloibiri, but it was not possible to state in what quantities until the results of the production tests were known, and these tests would be undertaken later this year. Oil had also been found at Afam, where preliminary drilling continued.

Vessels of the Federal Government of Nigeria had assisted H.M.S. Owen with the surveying work, but neither the Federal Government nor the Eastern Regional Government in Nigeria had participated in the mining operations. The Admiralty role had been limited to the survey work, but, said Mr. Soames, the Colonial Office had very much in mind the possibilities of developing oil resources in the area.

NEW B.O.A.C. AIRCRAFT

In a question put by Mr. A. E. Hunter (Labour), he invited the Minister of Transport and Civil Aviation to make a statement on what progress was being made in the negotiations between the B.O.A.C. and de Havilland Aircraft Company, Limited, for the construction of an aircraft sufficiently flexible both to meet the needs of the Corporation and to command a ready sale in world markets.

On these points, Mr. Harold Watkinson said that an aircraft had been evolved by de Havillands to meet a specification provided by the Corporation for a " pure jet all-purpose aircraft " which could serve both the North Atlantic and Eastern Hemisphere routes. Unfortunately, the prospects for the sale overseas of that aircraft did not appear to be promising, and there was no advantage in producing an aircraft which would be used by the Corporation only. In these circumstances, negotiations were being pursued by the Corporation with de Havillands and with a number of other aircraft companies regarding alternative possibilities, including one for the production of an aircraft not designed for non-stop Transatlantic operation, which aircraft might have more of a world-wide appeal.

PROGRESS AT LONDON AIRPORT

Among other questions put to the Minister of Transport was one by Mr. A. E. Hunter (Labour) and Mr. Arthur Skeffington (Labour) inquiring as to the steps being taken to construct earth walls at London Airport to combat aircraft noise there. Mr. Watkinson informed these Members that the British Overseas Airways Corporation had built two earth banks on the eastern boundary of its maintenance area and had agreed to extend these banks in step with the gradual development of that area. Negotiations had been opened by the Corporation with the Middlesex County Council to acquire the land needed for this extension.

Discussions were also proceeding with the various airline operators as to the most suitable layout and use of earth banks in the No. 2 maintenance area on the south-western perimeter of the airport. As to the time to be taken on these works, an estimate of the date for the completion of the scheme for this area would be made as soon as a satisfactory plan had been agreed to between the parties: planning was going ahead as rapidly as possible.

The Minister told Mr. David Jones (Labour) that the committee set up by the British Transport Commission to study the provision of a satisfactory rail-link between the Airport and the centre of London was now engaged in considering the interim report on the survey recently carried out by the consulting engineers concerned.

NUCLEAR POWERED SUBMARINES

Progress in the development of nuclear power for ship propulsion came before the House again last week. Mr. T. G. D. Galbraith, Civil Lord of the Admiralty, stated that scientists and naval officers serving at the Atomic Energy Establishment at Harwell had been collecting, for some years, the knowledge necessary for the application of nuclear power to marine propulsion.

Detailed work on the design of a prototype submarine nuclear power installation, which was shore based, was well advanced, and some orders for the prototype machinery had been placed. It was planned to construct a basically similar plant for installation in a sea-going submarine, and for its extensive trial.

The wider question of the further application of nuclear power to ships for both the Royal and Merchant Navies was being studied very carefully, and encouraging progress had been made with feasibility studies. Mr. Galbraith told Major P. H. B. Wall (Conservative) that the Admiralty, which, in the past, had successfully pioneered other forms of ship propulsion, was fully alive to the commercial opportunities opened up by developments in the use of nuclear power. He assured Mr. A. G. Bottomley (Labour) that there was the fullest co-operation regarding research in respect of merchant shipping and ships for the Royal Navy in order to secure the best results.

NUCLEAR POWERED LOCOMOTIVES

The use of nuclear power for other forms of transport was also discussed. The Paymaster General, Mr. Reginald Maudling, said that the application of nuclear power to road vehicles or to railway locomotives was not practicable at present. He told Captain R. A. Pilkington (Conservative) that the nuclear propulsion of aircraft also presented considerable difficulty, but that preliminary studies had been made and that there had also been discussions with industry on the subject.

Mr. Hector Hughes (Labour) asked for information as to the difference in costs indicated at the recent conference of the United Kingdom Atomic Energy Authority, Harwell, between the nuclear propulsion of ships and the methods at present in use. In reply, Mr. Maudling said that the Lord President of the Council, the Marquess of Salisbury, had been informed that investigation into the nuclear propulsion of ships was still in too early a stage for the gap in costs to be estimated. The main purpose of the work that was being done was to find a method which would make the nuclear propulsion of ships commercially attractive.

ATOMIC ENERGY FOR CIVIL USE

Mr. Maudling informed Dr. B. Stross (Labour) that the agreement between the Governments of the United Kingdom and the United States for co-operation on the civil uses of atomic energy provided for exchanges of information over a wide field.

This co-operation was effected through the regular transmission of reports between the United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority, and by frequent exchanges of visits by experts of the two countries. In addition, the Atomic Energy Authority maintained a scientific liaison office in Washington, and the Atomic Energy Commission had recently established a similar office in London. Opportunities for the mutual exchange of information also resulted from the participation of the United Kingdom and the United States in international conferences, and in the work of international organisations concerned with atomic energy.

Opposition to Trade Unions

On the application of Mr. Ian Mikardo (Labour) a Bill to invalidate rules of friendly societies which discriminate against membership of trade unions was presented to the House and read a first time. Arrangements were also made for its second reading next Friday.

Mr. Mikardo stressed the importance of good industrial relations and pointed out that everybody in the country, with but few exceptions, accepted the fact that it was in the widest national interest that both employers and employees should organise themselves into appropriate associations and unions, in order to have a common voice in speaking to each other and of communicating with the Government of the day.

There were instances, however, where the resistance which was formerly shown by some employers to the growth of trade unions among their shop-floor workpeople had been transferred into resistance to the growth of trade unionism among the white-collar employees: the foremen chargehands, the departmental heads, managers, technicians, designers and draughtsmen. One of the means which this resistance took was the sponsorship by employers' organisations of friendly and benefit societies. Of themselves, these bodies were worthy institutions and did good work. The employers nominated to membership of the societies their foremen and other personnel, but only on condition that such persons were not, or did not remain, members of a trade union.

Pressure of this kind was not only subtle but quite powerful and it had had a considerable effect. The trade-union movement had been very concerned about it for a long time.

Advising Engineering Employers

The Minister of Labour and National Service, Mr. Iain Macleod, told the House that he understood that the unions concerned with the recent wage claim in the engineering industry had requested a further meeting with the Engineering and Allied Employers' National Federation, and that, therefore, no action was called for from the Ministry at that stage. Mr. Macleod gave an absolute assurance to Mr. A. W. J. Lewis (Labour) that the Government had not advised the engineering employers against granting increases. It was no part of the Government's duty to advise an organisation of employers either to accept or to reject wage claims.

Restrictive Practices

The Ministry's National Joint Advisory Committee, Mr. Macleod told Mr. Frederick Lee (Labour), had by no means completed their study of restrictive practices in industry, but the results so far reported offered encouraging evidence of employers and workers tackling the problem jointly in a spirit of mutual co-operation.

Work for the Elderly

Mr. E. S. T. Johnson (Conservative) raised the problem of finding employment for the older workpeople and asked for a statement about the present activities of the committee appointed to investigate these questions. He was informed by Mr. Robert Carr, the Parliamentary Secretary to the Ministry of Labour, that the National Advisory Committee had already published two reports which made recommendations for promoting the employment of elderly persons. The Ministry took active steps to encourage the implementation of these recommendations, and there was evidence of a greater willingness by employers to consider older workers on their merits, without regard to their age. For the present, the Committee was concentrating on encouraging research into specific problems associated with the employment of such persons.

THE HUMAN ELEMENT

Wage claims and the national cake—Pay claims in the Civil Service—High Court judgment on a contract of employment—The foreman and industrial safety—Labour troubles at Briggs—Inter-trade wrangling and the export drive.

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"Higher and Higher"

The words—Higher and Higher—were part of a song popular among youths in the 'thirties who watched with delight the rise of the Soviet star. To-day it is their wages that go up and, from all accounts, there are seven million in the pay queue with outstanding wage claims and the sky's the limit. The crash could be most unpleasant and even the strongest partisan of the workers' rights should feel a little uncertain about the rate of climb. The wise old heads of union leadership will no doubt act as ballast: anchors are out of the question where pay is concerned.

During 1956 weekly wage rates rose by 7½ per cent. while the retail price index rose by only 3 per cent. This represents a record gain in real terms for the sweating masses. But is it so real? The figures make somewhat stale reading now. In February there is increasing unemployment in motor vehicles, aircraft and ancillary trades. Transport is short of fuel and building short of money. In fact, the balloon's sides are distinctly flapping and still the wretched Government are letting gas escape.

Seven million workers are awaiting settlements on wage claims. Last year 12½ million were successful in gaining awards to an aggregate of £343 million a year. But we are told by a most eminent and respected American engineer (Weekly Survey, this week) that our wage rates are much too low anyway, one-third to one-half of the American, and that it does not help much with our prices (*i.e.*, they are not competitive anyway). All in all, it's a very complicated business.

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Work Study on Technical Grades?

Feeling is growing among the technical grades of the Civil Service about their status compared with administrative workers. The latest sign of this is a strongly worded statement by the Institution of Professional Civil Servants on what it considers to be the delaying tactics of the Treasury in considering the claims for better pay of the Technical Classes in the Civil Service. Among other objections the Institution raises the one concerning the wish of the Treasury to wait for a special investigation by the Civil Service Pay Research Unit. It gets not a little satisfaction from the decision of the Civil Service Arbitration Tribunal to publish its findings on the whole subject early this month.

This displeasure over the Treasury's attitude goes deeper than the immediate issues raised by the Priestley Commission on Civil Service salaries. The attitude (though it may be partly sub-conscious) rises from a feeling that there is a basic and permanent prejudice in favour of the administrator and against the engineer and scientist. Furthermore, the Institution sees in the Treasury both the arbiter and an interested party since it is above all an administrative body itself.

The problem is a difficult one. There are obviously cases where the highest paid activity is that of the administrator and very often he gets his experience through a technical background. There are also cases where the administrator is more highly paid for reasons of long-standing prejudice. In industry at the present time the free market is working to adjust the balance to some extent as the shortage of technical people becomes chronic. In the Civil Service the market works slowly through principle and precedent. There would be much to be said for a work study investigation of both types of salary earner in the Civil Service.

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Terms of Employment

An engineering operative has recently been the subject of an important ruling by the High Court on terms of employment. The employee took up his job in 1944 and signed an agreement that he would not work for a competitor within two years of leaving the company. In September, 1956, he left and three days later he started for a competitor. His former employers therefore sought a High Court order directing him to leave his new job since it infringed his agreement with them. The judge ruled that the clause in the agreement was void since it was not in the public interest that a man should be prevented from pursuing his trade or profession.

The object of the clause in the original agreement was to prevent an employee passing on any of the company's secrets to a rival. The ruling of the court is not concerned with trade secrets, however, but with limitations in general which a concern can put on the movements of its workers. No doubt this kind of condition of employment has been written frequently into terms of employment, employers hoping that it will act as a deterrent.

In principle the decision of the court will have wide approval. It is clearly intolerable that the mobility of labour and a man's right to earn a living should be at the mercy of any particular concern's desire to protect its "secrets." What a trade "secret" might be in the eyes of the law could be a fruitful source of argument for long enough. Generally, the tendency for this kind of clause to go into the employment conditions of men working on the shop floor is a sign of conservatism at the top rather than possession of any unique "know-how." British industry already suffers severely from secretiveness. This case may have helped slightly to break it down.

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Accidents and Human Relations

Some interesting remarks about the inter-action of organised safety measures in factories and good management-labour relations are made in a report of a mission to the United States into accident prevention. The results of the visit have now been published in booklet form by the European Productivity Agency with the title of *The Prevention of Occupational Accidents in the United States*.

The cost of industrial injury both to production and in a social sense are generally known. The prevention of injury is, however, all too often one of those subjects (like fire prevention) which raises little enthusiasm anywhere in the organisation of the company. The mission found in its travels that the Americans have done a good deal of systematic work which has paid off in several ways. In all cases, however, there has had to be an investment of time in the subject from the general manager down, and a systematic approach made to instruction of personnel, responsibility and lines of communication. Where this has been done there has been a dividend outside the reduction of overheads directly due to industrial accidents.

Two of the most interesting indirect gains have been in the added importance of the foreman who, in most cases, has been the main object of systematic instruction and the recipient of delegated authority. In addition, the general increase of interest in the subject of accident prevention throughout the organisation has created a forum which has played a part in improving human relation. The reason is not far to seek. A man who becomes convinced that the company wants to look after him and seeks his co-operation is a man who thinks he matters.

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Communists Versus A.E.U.

The situation at Briggs is bad but it has its funny side—from the onlooker's point of view, at any rate. No plant could have a worse record for labour relations. In the 15 months to November, 1955, there have been 289 stoppages. For reasons which have yet to come to the full light the 9,500 workers provided themselves with lay representatives of the extreme left. The shop stewards were a spear in the management's side, and it would seem the latter were not clever at side-stepping even clumsy attacks. With practice, the stewards, who include a large Communist element, got better and this time they scored a major victory at the expense of the Amalgamated Engineering Union. The funny part comes next: the A.E.U. executive instructed their new Communist member to call the men back to work! But the word can mean different things nowadays and the union's move may have been a very good one—if it had come off.

The shop stewards called a mass meeting on February 1 and got the terms agreed between the management and the A.E.U. rejected by a two-to-one majority. These terms had been that work should be resumed, and an immediate investigation started into the circumstances in which five shop stewards were suspended and one of them, a Mr. J. McLoughlin, dismissed. The management had taken this action against the stewards because of a breach of the disputes procedure. It came as no surprise and is readily understandable, but a strike started immediately, whereas the shop stewards had failed to bring one about when the management declared 1,750 men redundant at the end of last year.

Much remains to be done at Briggs which the Ford management have yet been unable to do since they took over control in 1953. A call for a full inquiry into industrial relations at the plant has been made by Sir Thomas Williamson, general secretary of the National Union of General and Municipal Workers and chairman of the T.U.C.

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The Britannia—An Object Lesson

The beginning of commercial operations by the Bristol Britannia last week was an auspicious engineering occasion. It was an event of historic importance and world interest. It was also marred to some extent by a row between B.O.A.C. and the union concerned about the engineering maintenance side of its operations. At a moment of world-wide publicity for the aircraft, a wrangle about instrument panel construction was the only curtain raiser that British industry could offer. Whatever the relative merits of the case may have been, the affair was bound to look petty and slightly comic to people abroad who are told (at considerable expense to shareholders and taxpayers) how seriously this country takes its aircraft export drive—and how successful it is.

It emphasises once more what a complicated affair industrial activity is in the Twentieth Century. It is not necessary only to produce an excellent piece of engineering equipment and sell it. You have to take a cumbersome burden of vested interests along with you from the Ministry of Civil Aviation to the trade unions concerned in the making and operation of the device. It may add up to a nightmare world for the technician but for better or for worse it is the world he lives in. Let it be remembered that the Britannia flies by courtesy, not only of the chief designer of the Bristol Aeroplane Company and his team of men, but also by that of a lot of other intellectually smaller men who twiddle screwdrivers for the next ten years and fill in forms. They could never build an aircraft but they can keep it on the ground. We have all been warned.